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(54) **OPERATING MECHANISM FOR A VERTICALLY ORIENTED BODYMAKER**

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(51) **Int. Cl.**

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B21D 51/26	(2006.01)
B21D 35/00	(2006.01)
B21D 37/12	(2006.01)

(52) **U.S. Cl.**

CPC ***B21D 22/28*** (2013.01); ***B21D 51/26*** (2013.01); *B21D 35/003* (2013.01); *B21D 37/12* (2013.01)

(58) **Field of Classification Search**

CPC B21D 22/28; B21D 51/26; B21D 22/30; B21D 22/00; B21D 24/12; B21D 24/16; B21D 35/003; B21D 37/12; B21D 51/38; B30B 1/14

See application file for complete search history.

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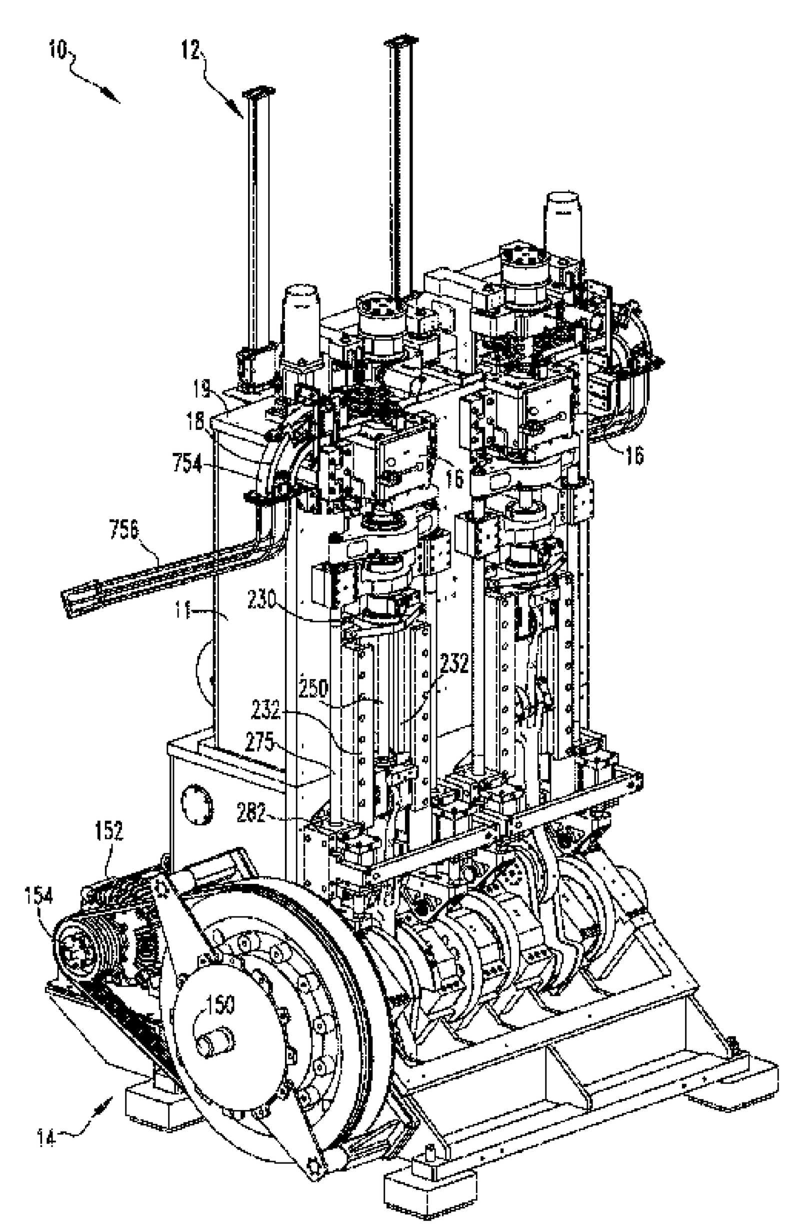
(57) **ABSTRACT**

A can bodymaker is provided. The can bodymaker includes two rams that travel over a generally vertical path. The body-maker includes a housing assembly and an operating mechanism structured to move a number of ram assemblies over a vertical path of travel. The operating mechanism includes a crankshaft, a motor, a link assembly, and a number of ram assemblies. The crankshaft is rotatably coupled to the housing assembly and includes a number of pairs of crankpin journals. The motor is operatively coupled to said crankshaft. The link assembly includes a number of links. Each ram assembly includes an elongated ram body, each ram body structured to move over a ram path. Links from said link assembly extend between, and movably couple, each crankshaft crankpin journal to a ram body.

4 Claims, 15 Drawing Sheets



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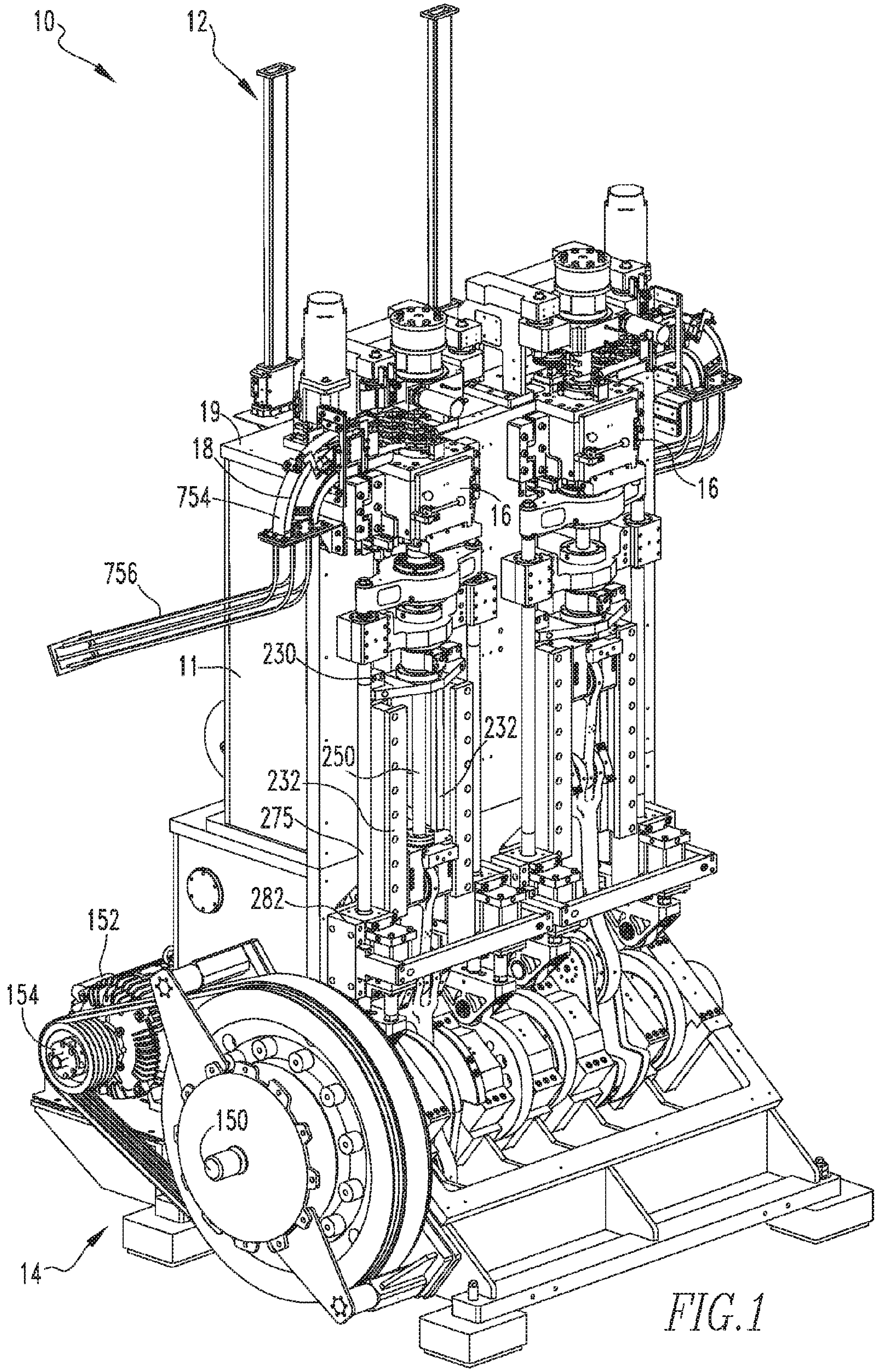

FIG.1

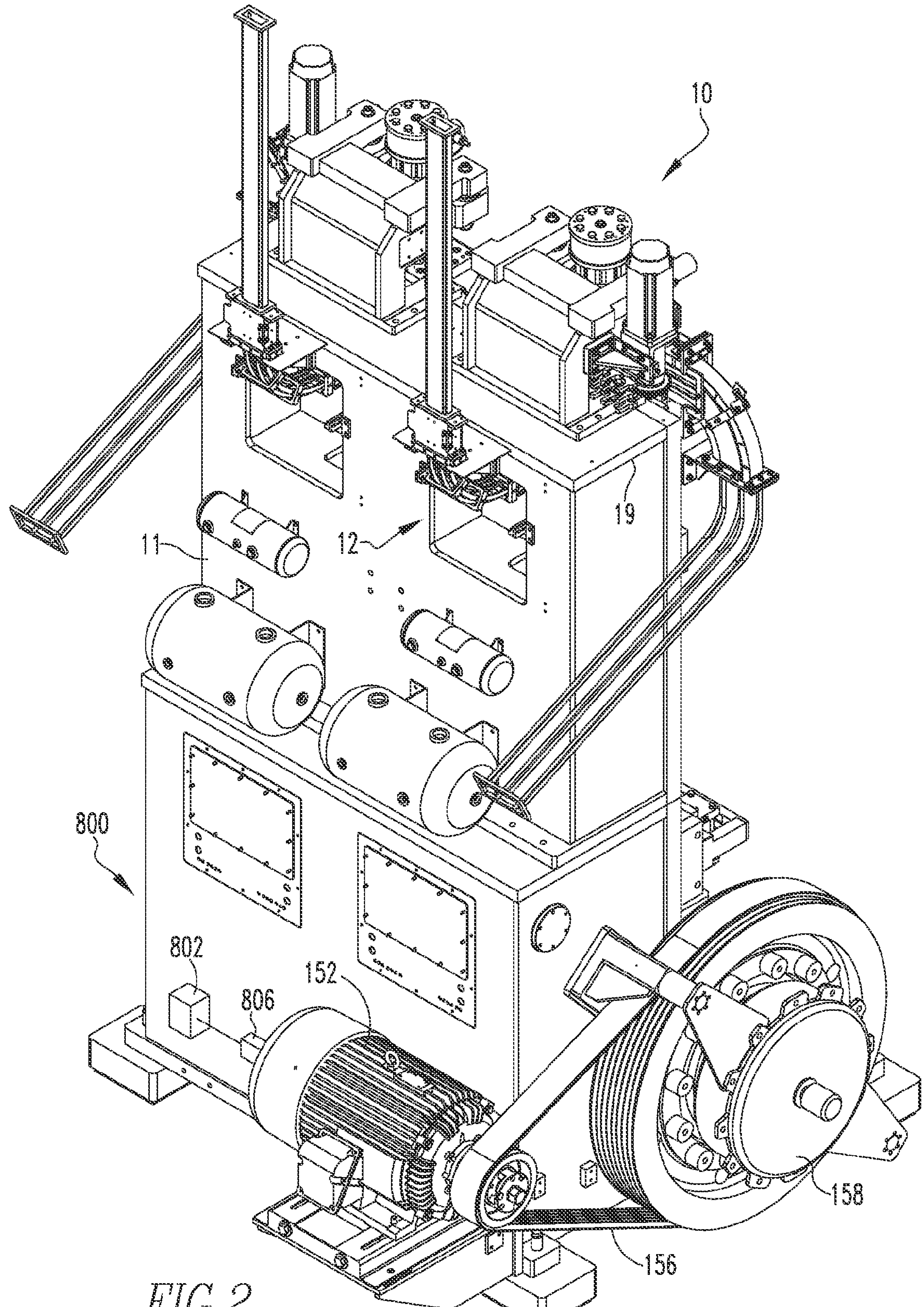

FIG.2

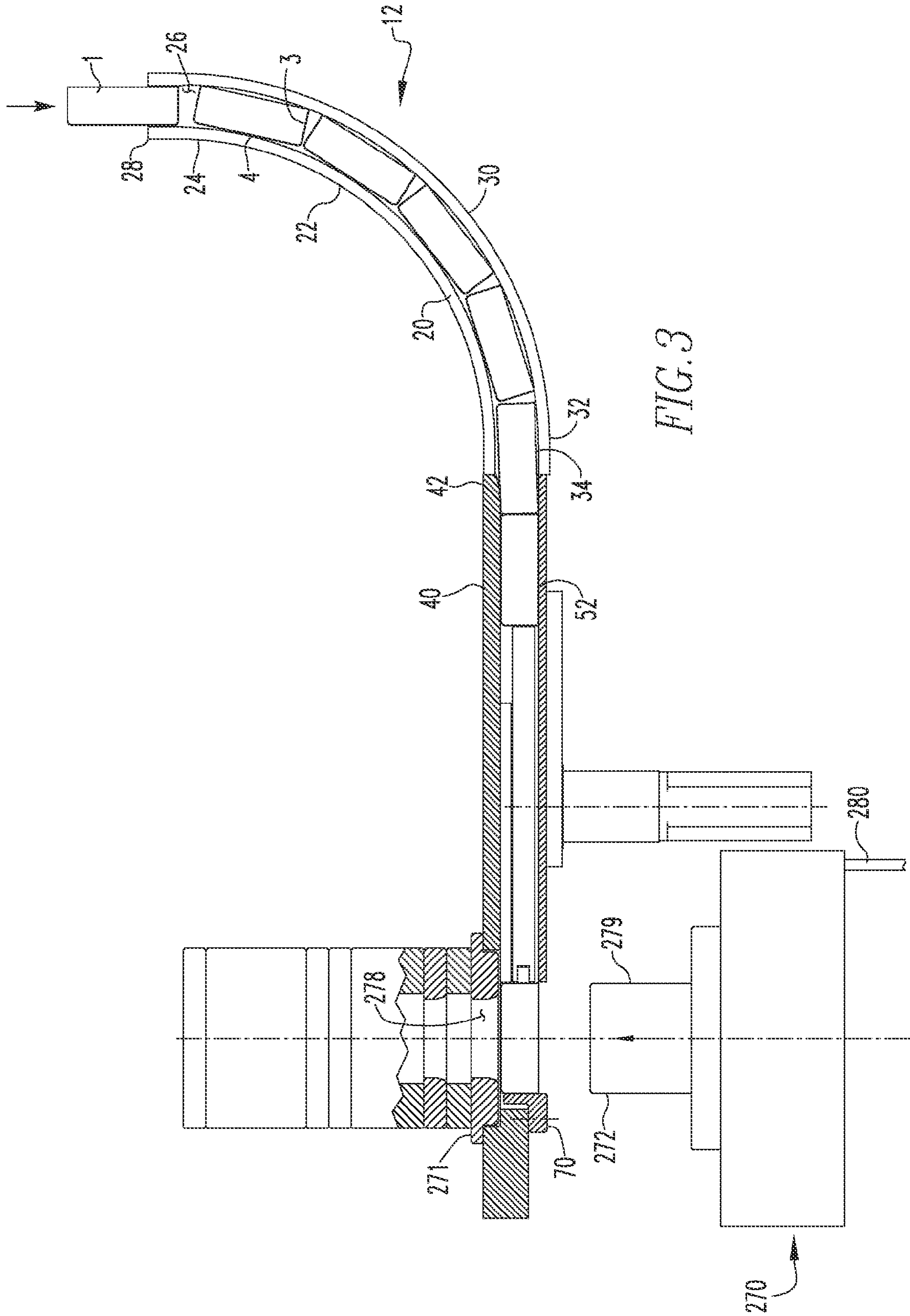

FIG. 3

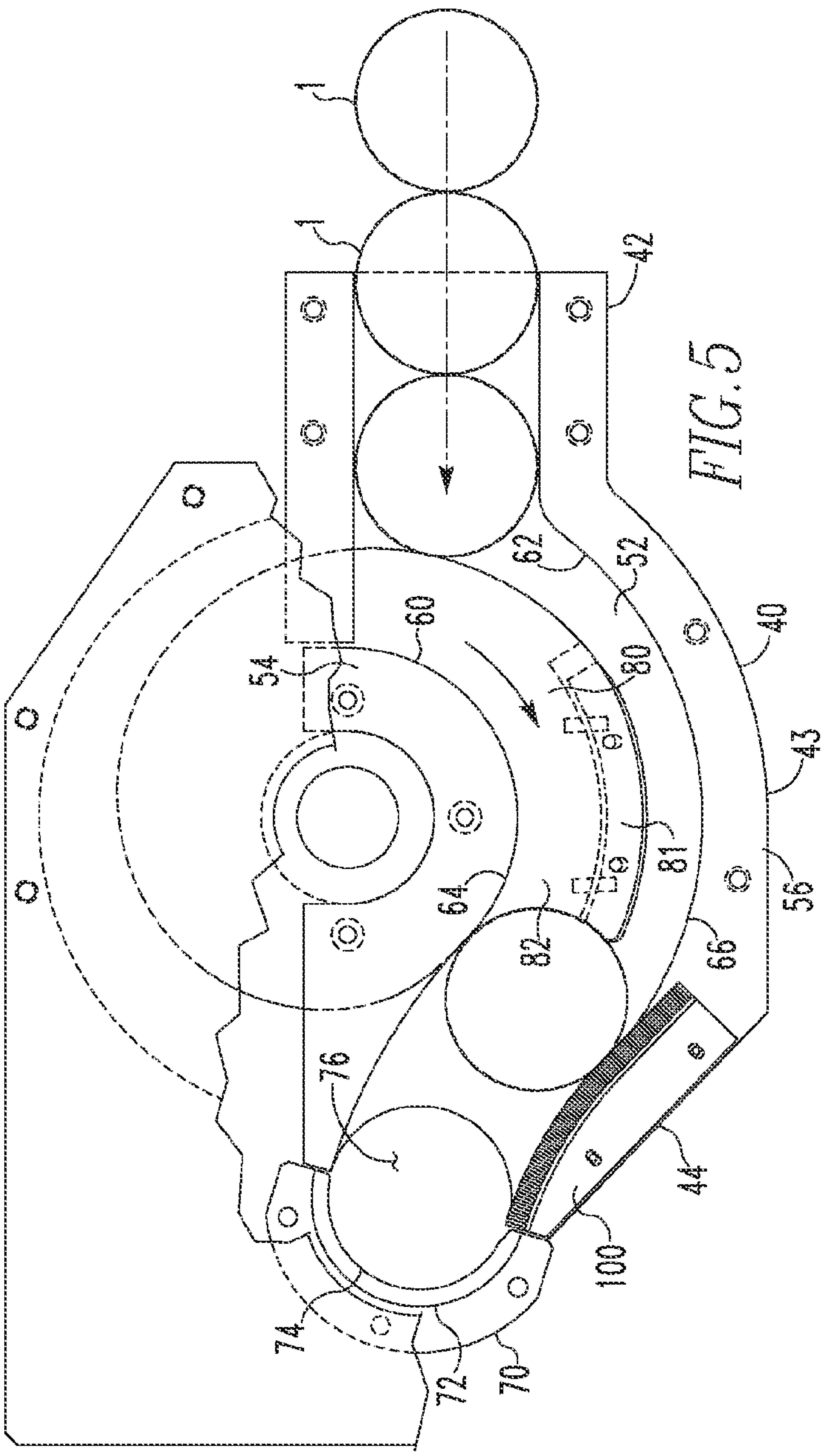

FIG. 5

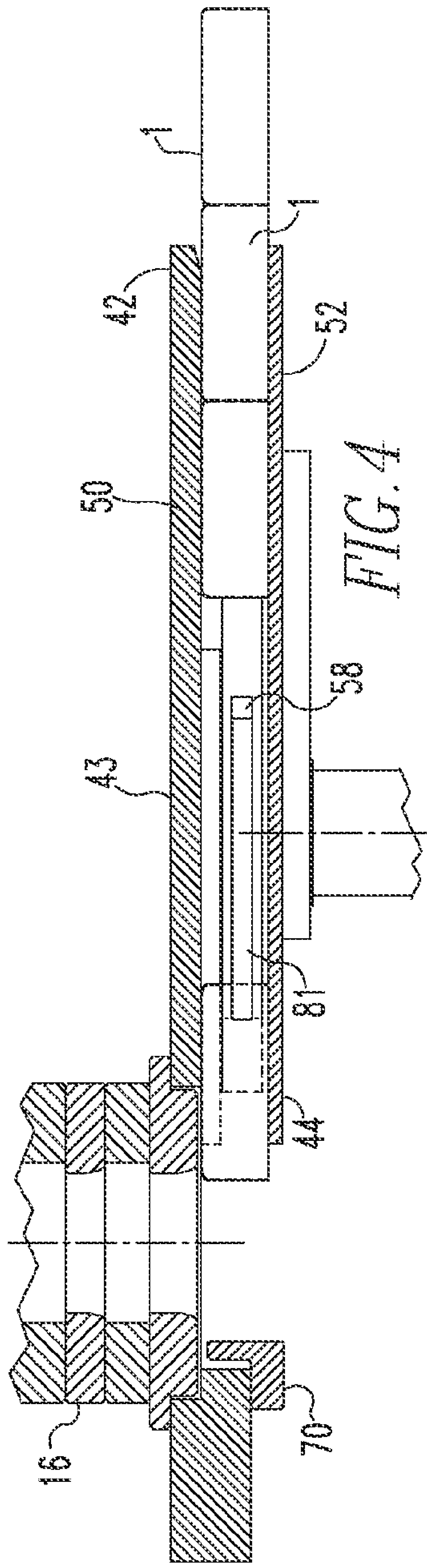

FIG. 4

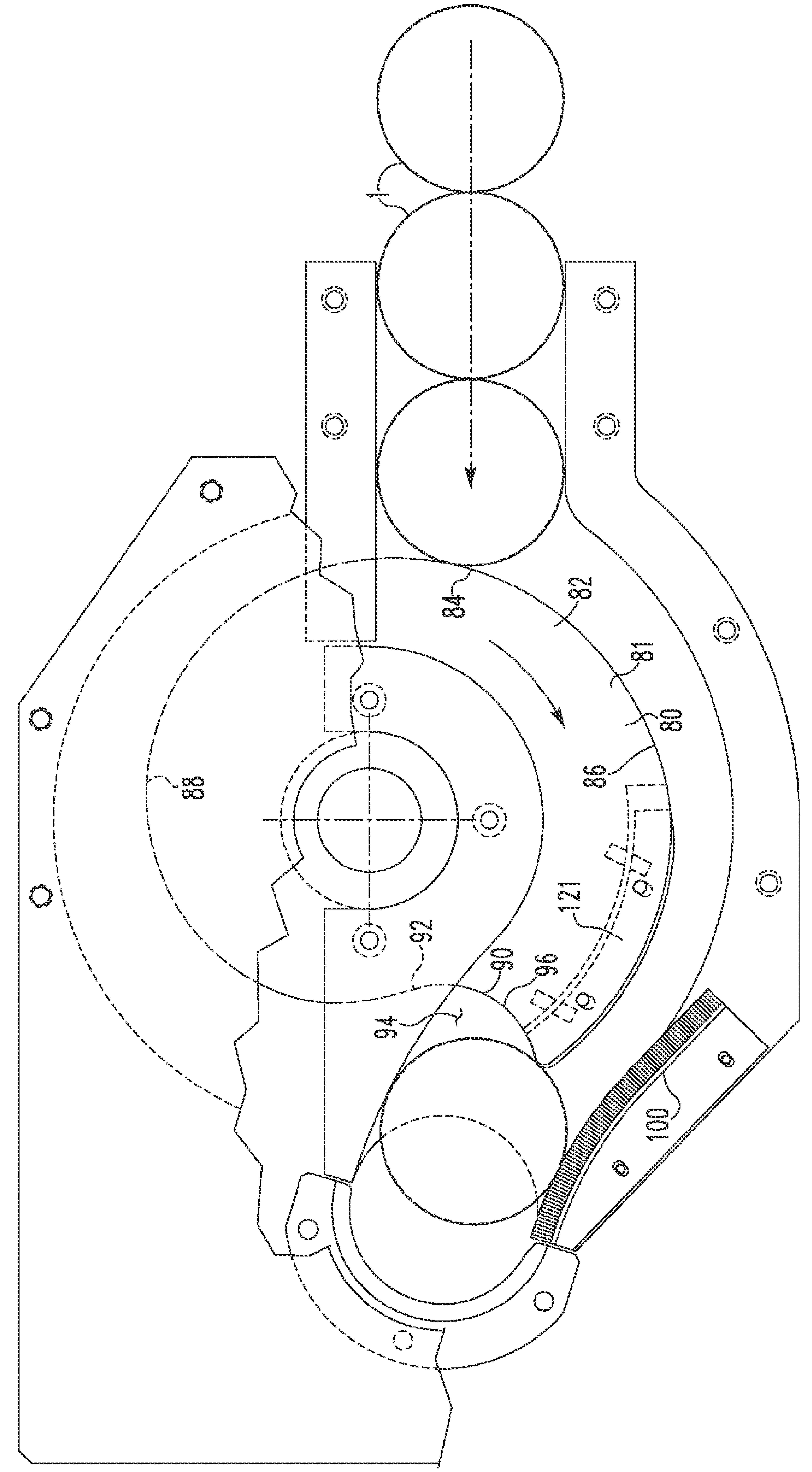

FIG. 6

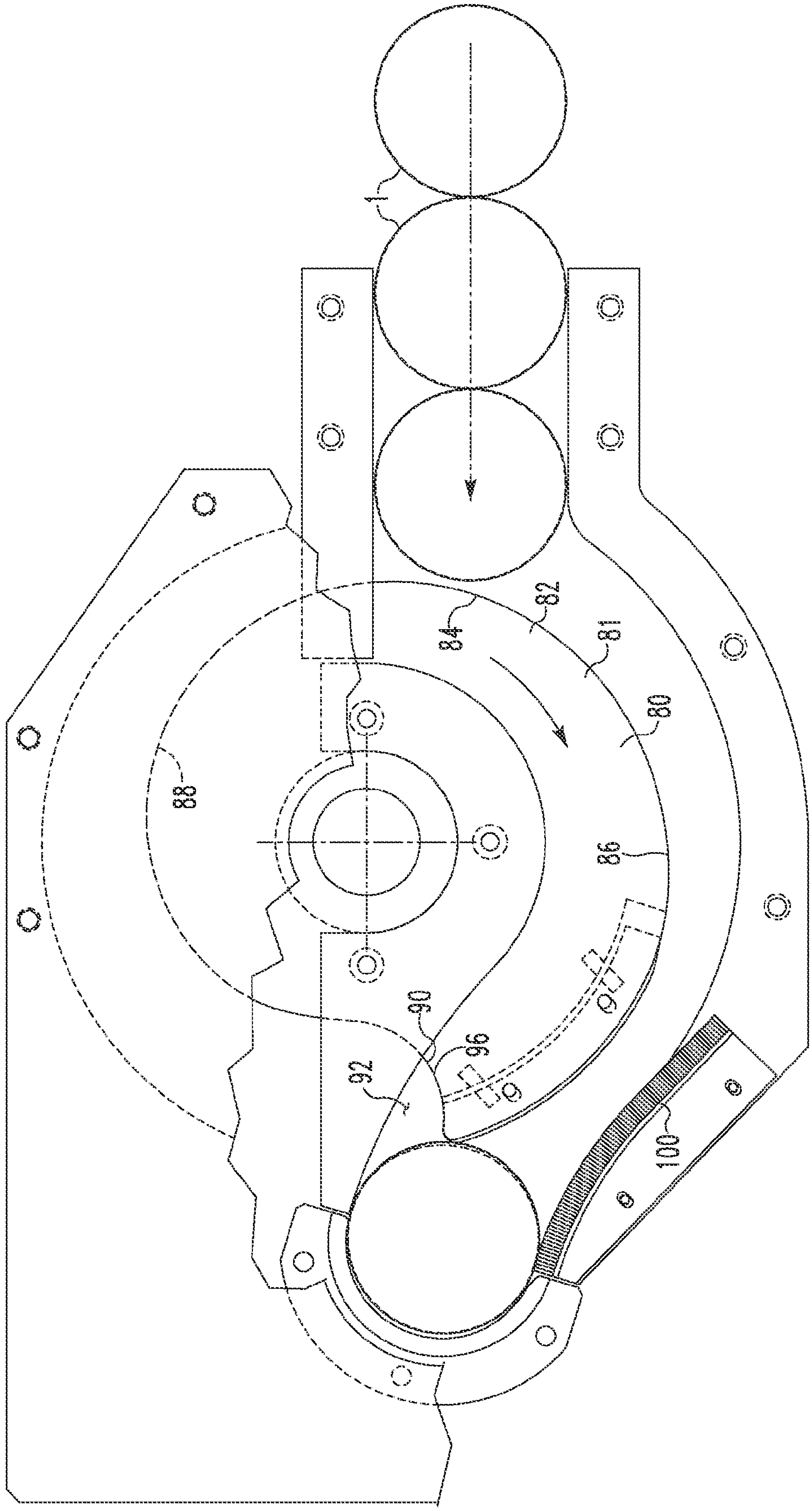

FIG. 7

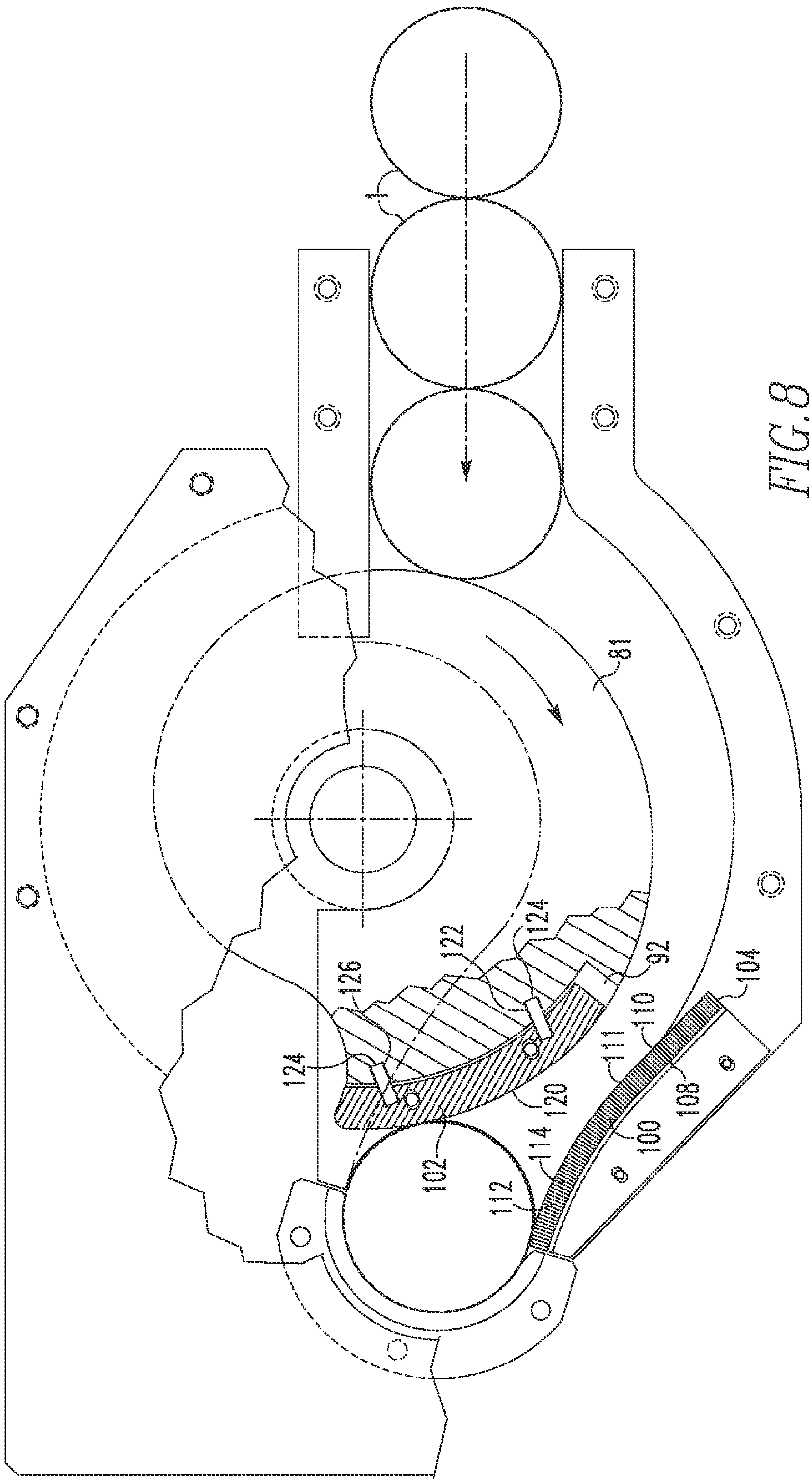

FIG. 8

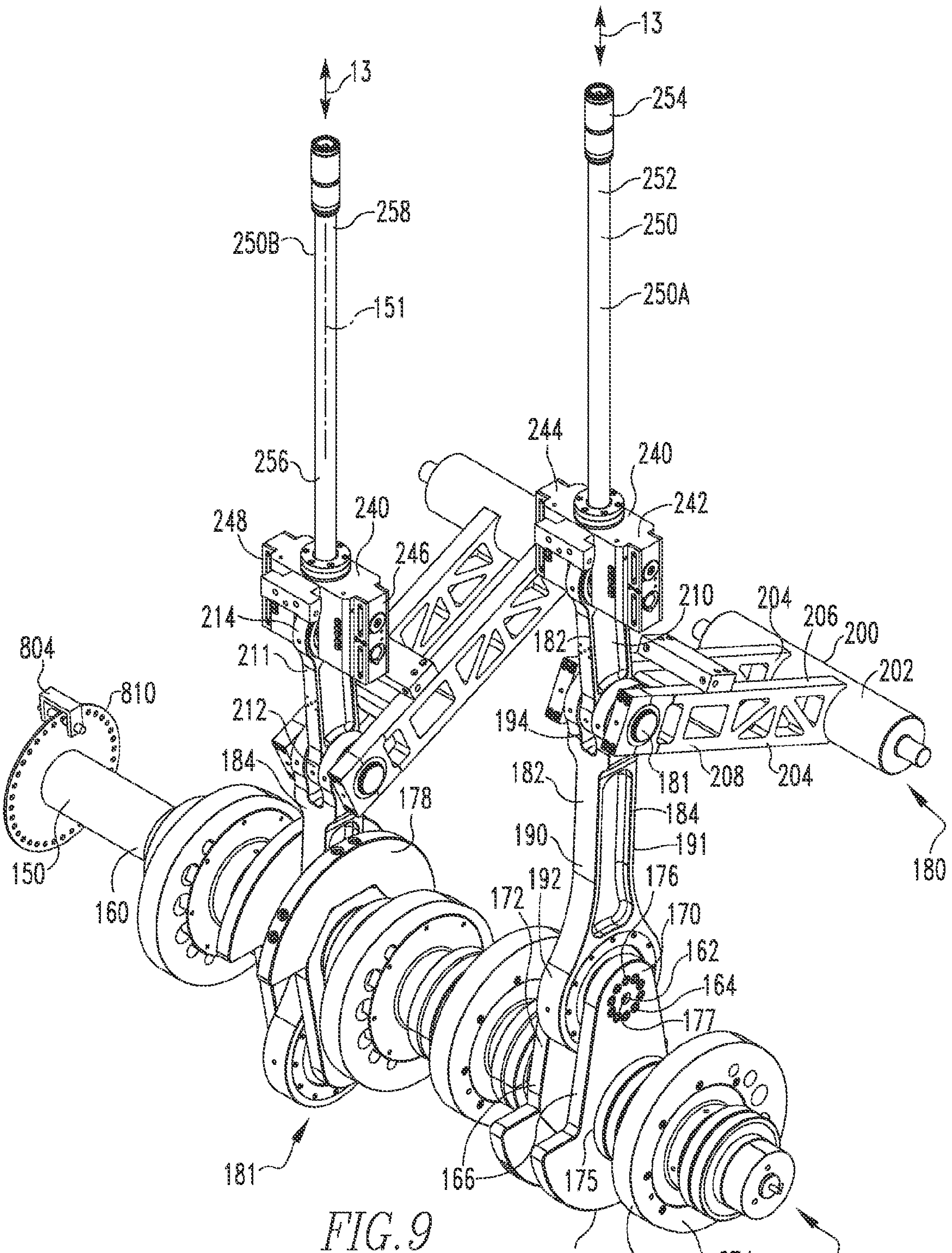
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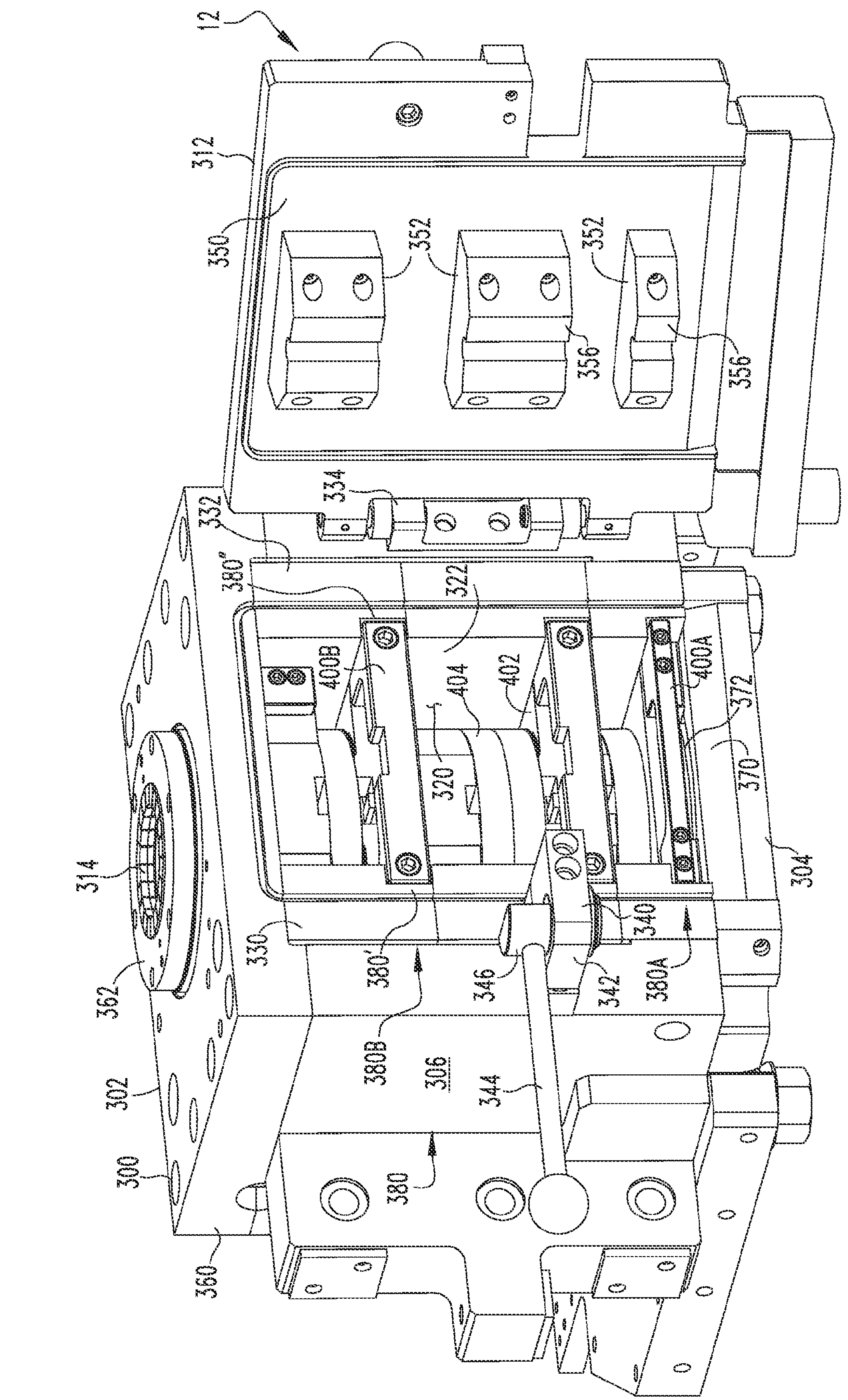
FIG. 9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380B
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302
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380
360

FIG. 10

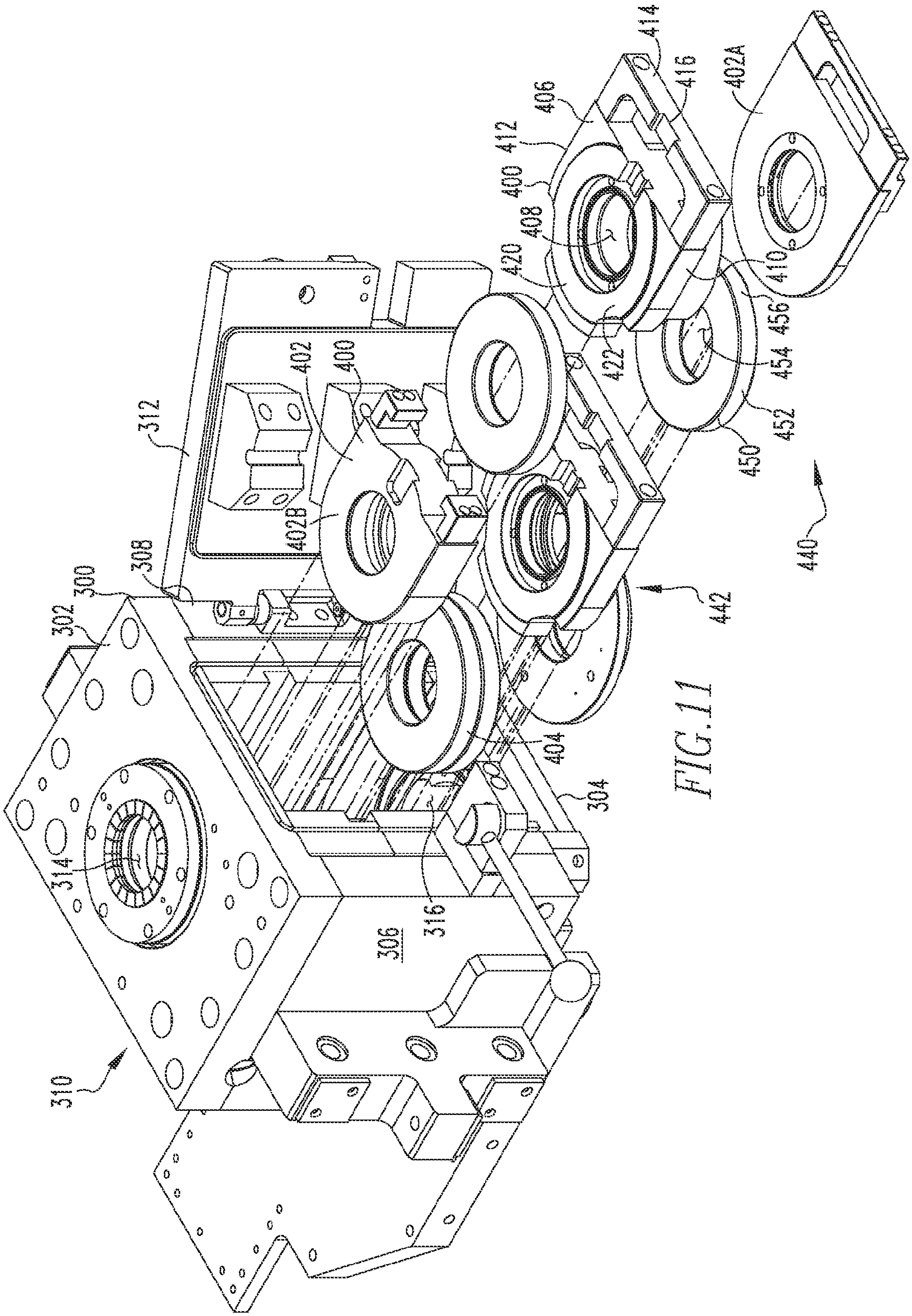
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FIG. 11

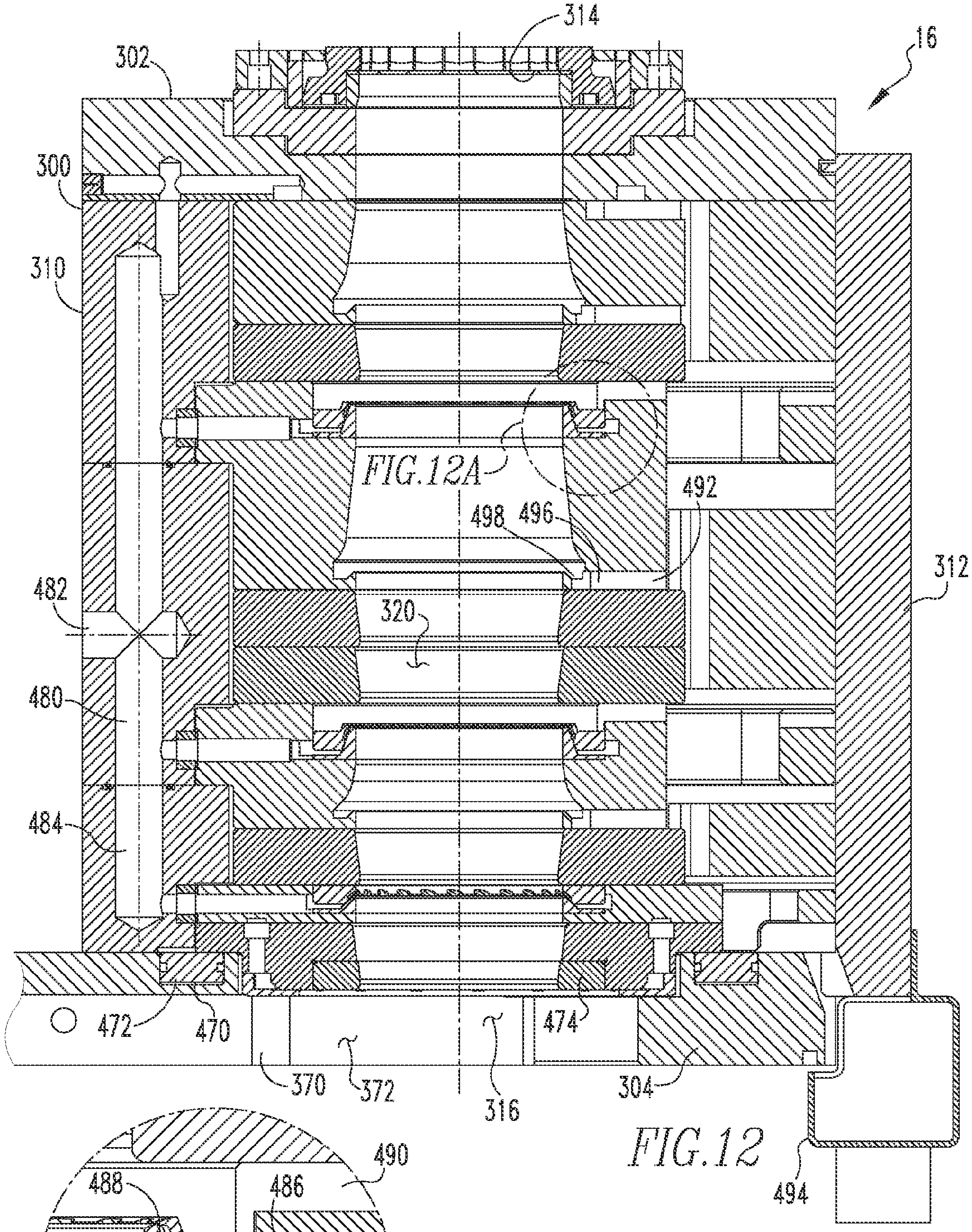


FIG.12

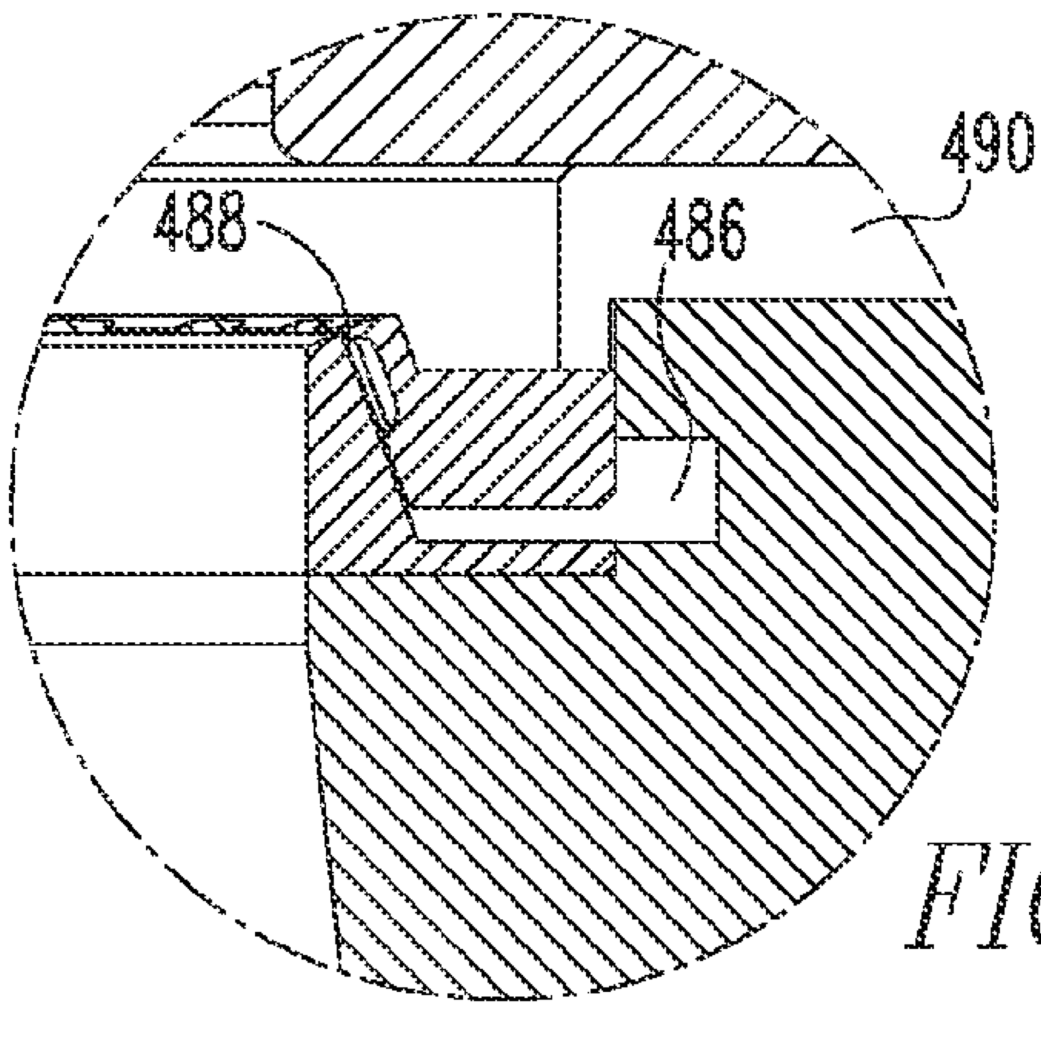
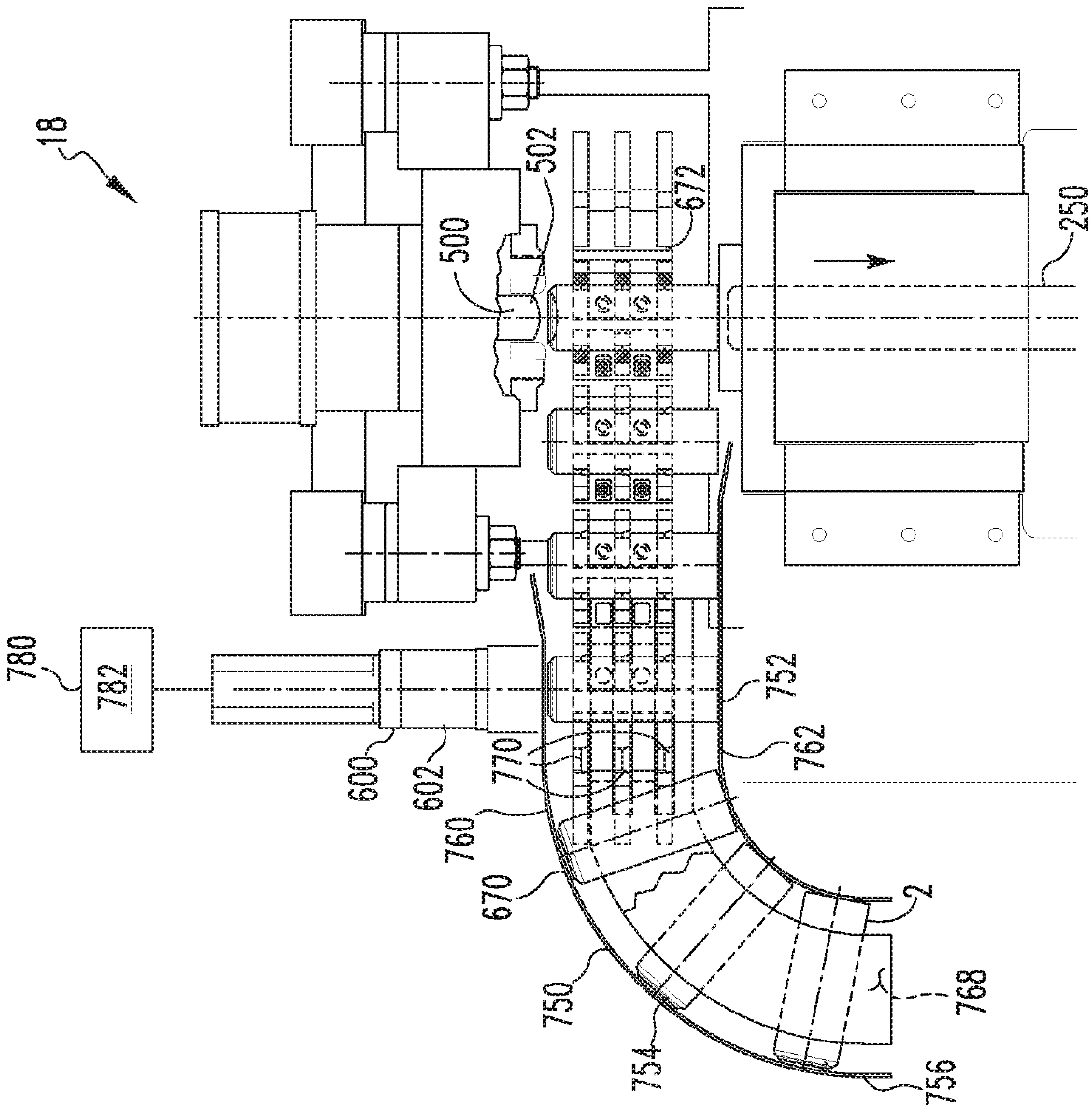


FIG.12A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762
760
670
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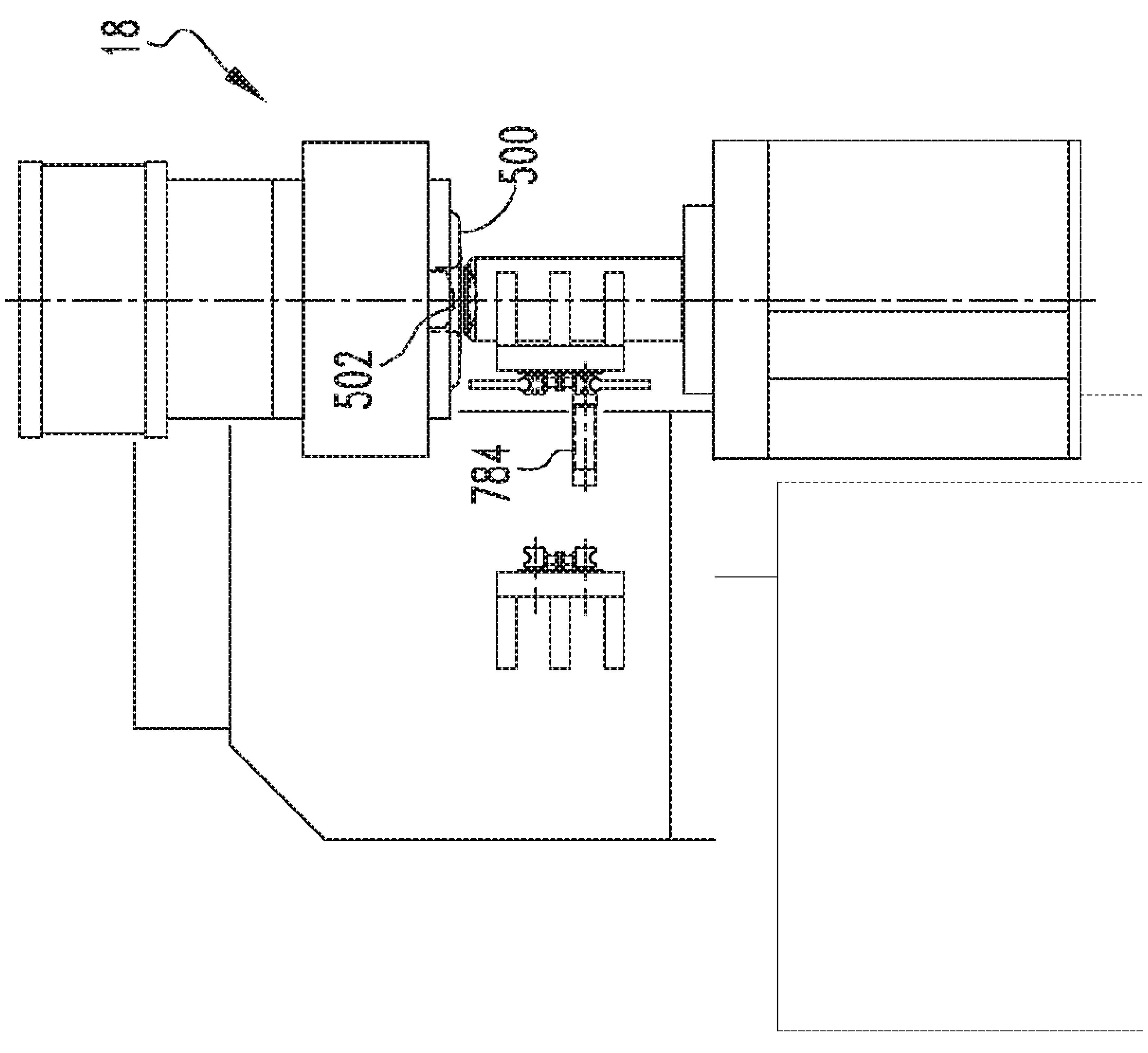
756

FIG.13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502
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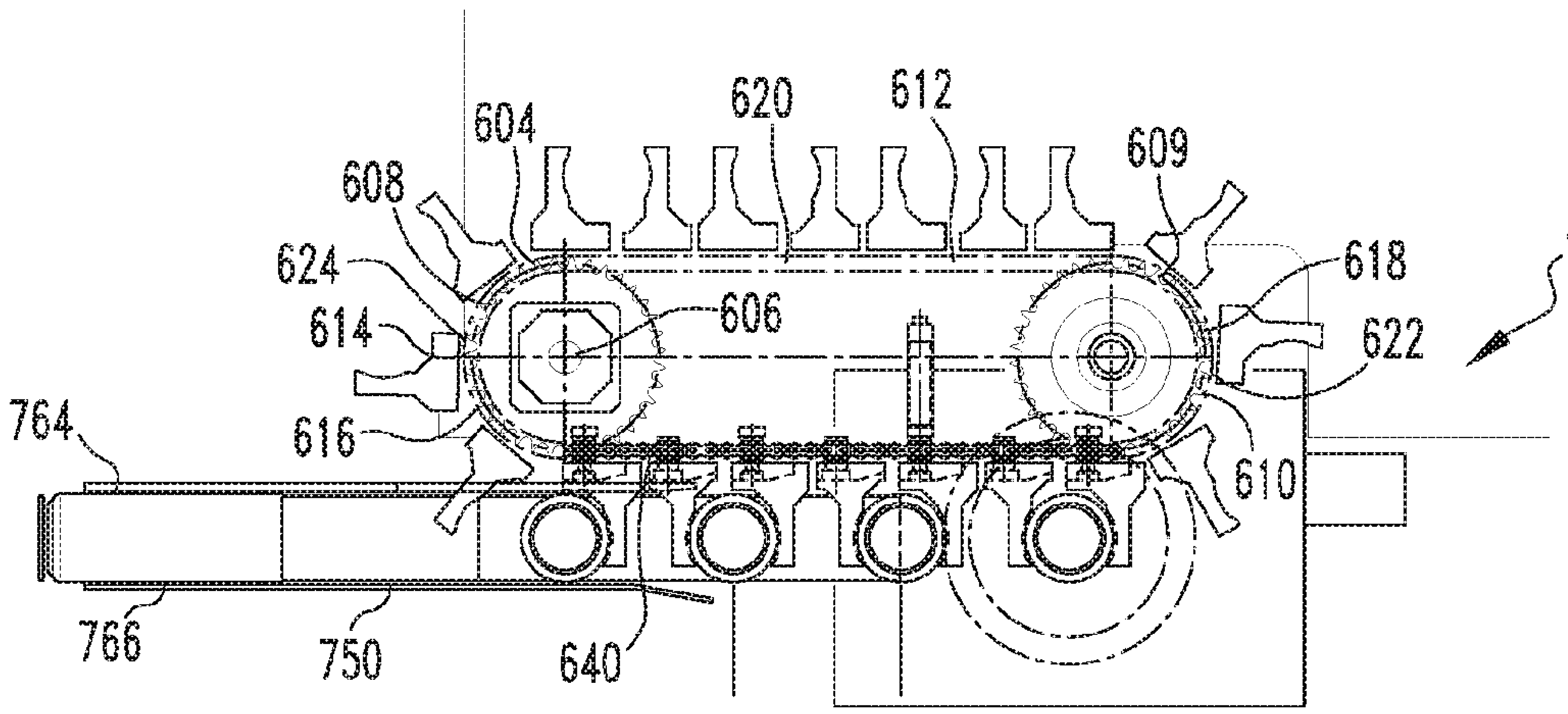
FIG.14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766
750
640

FIG.15

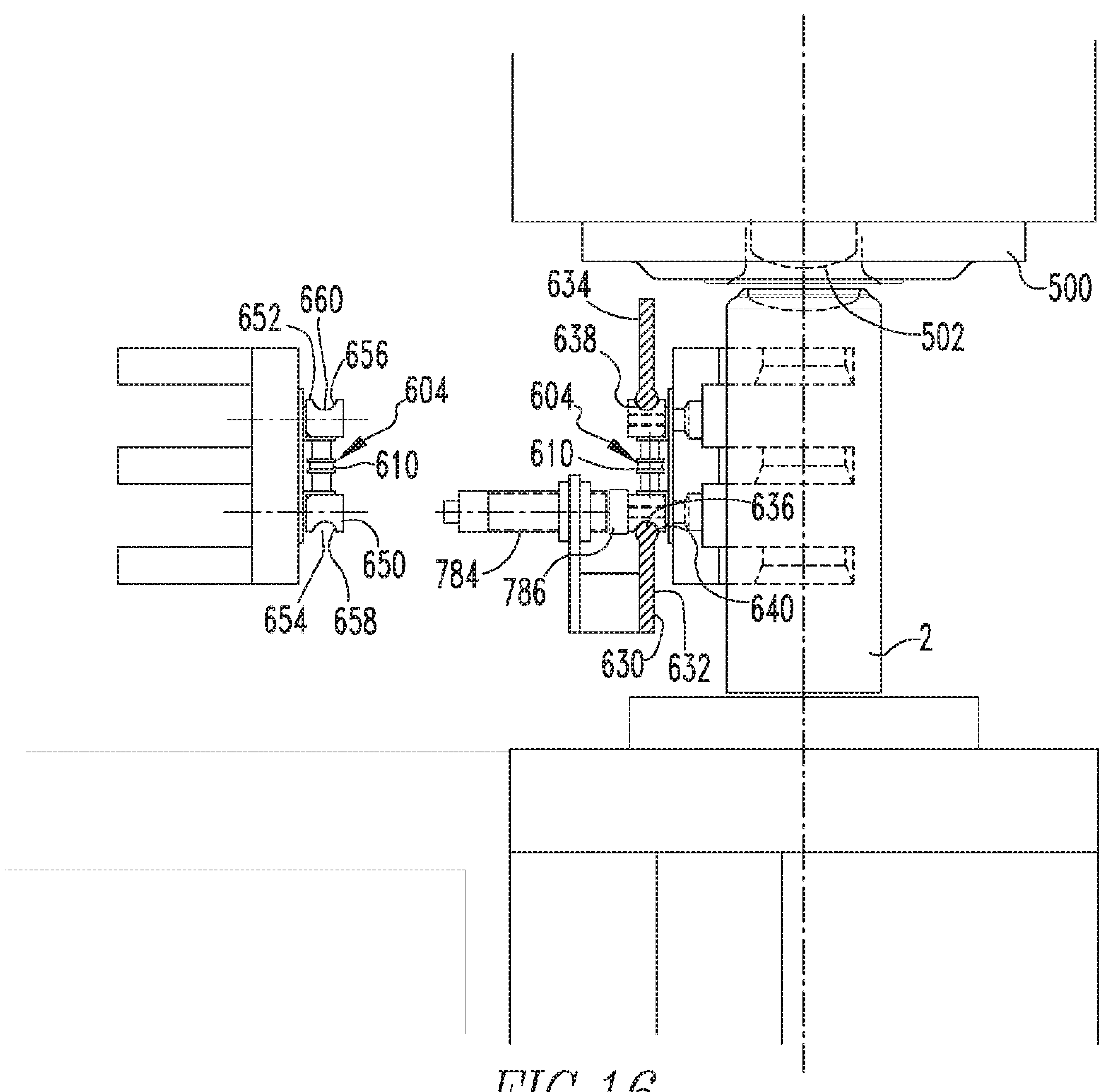
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FIG.16

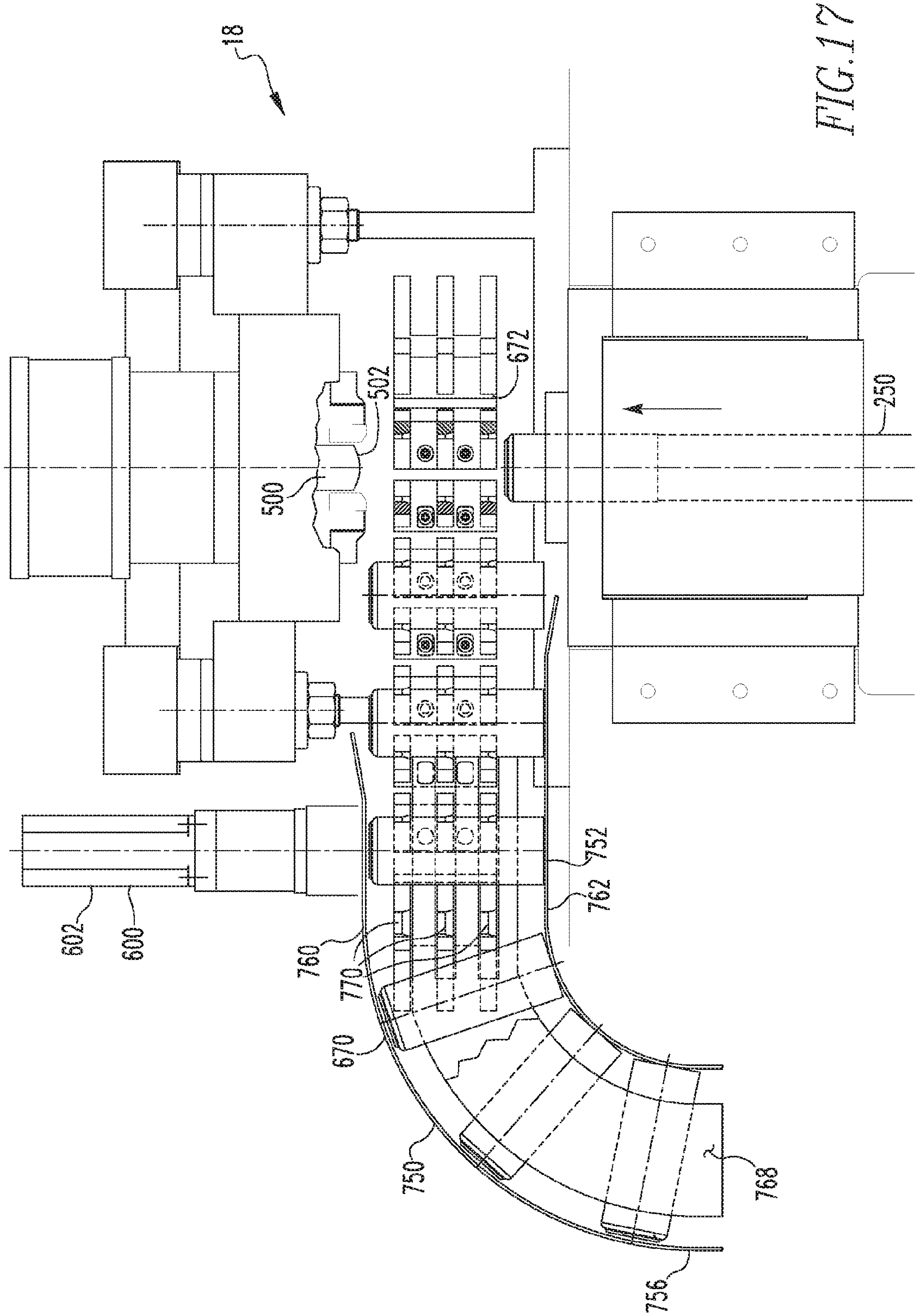
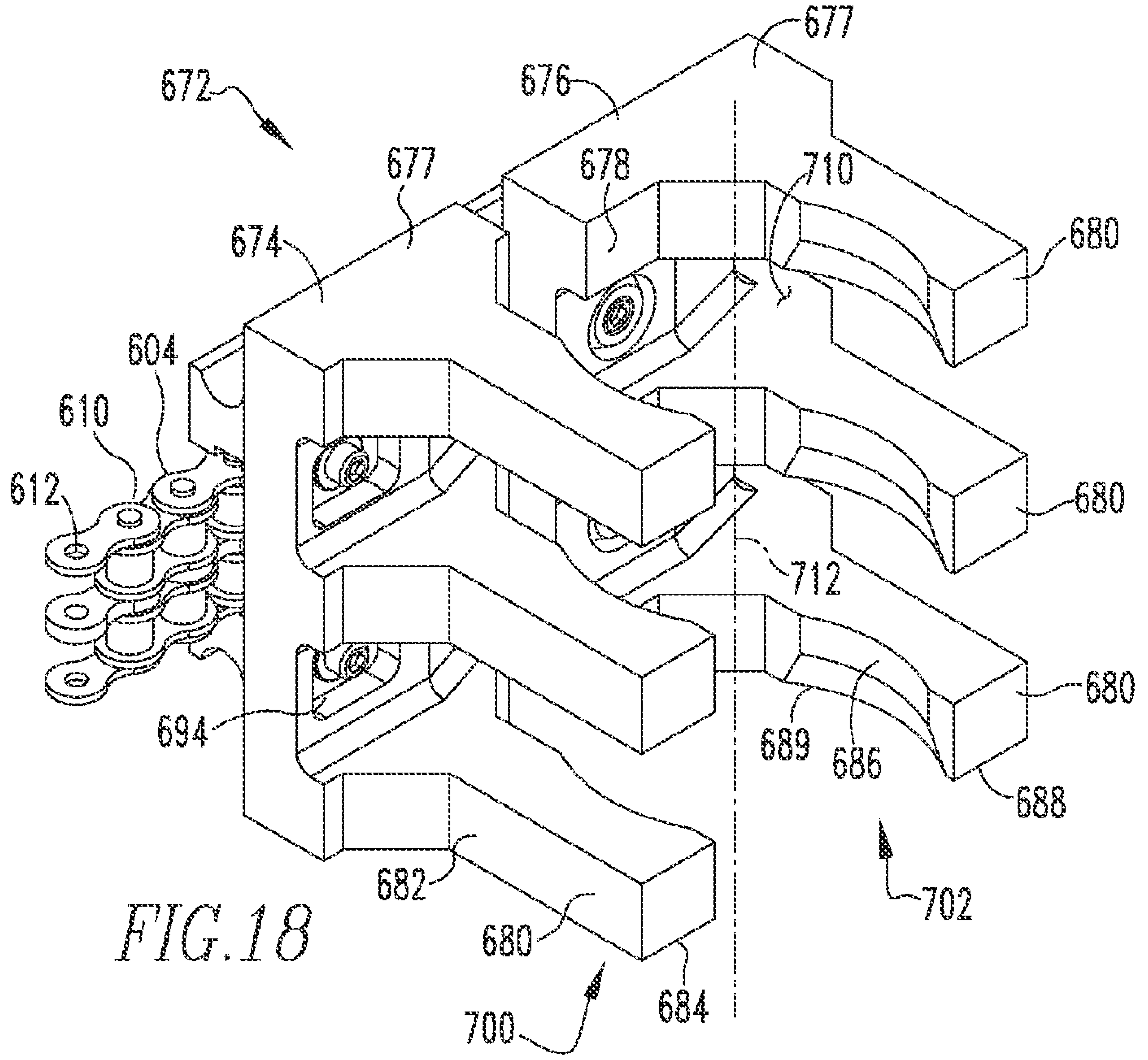


FIG. 17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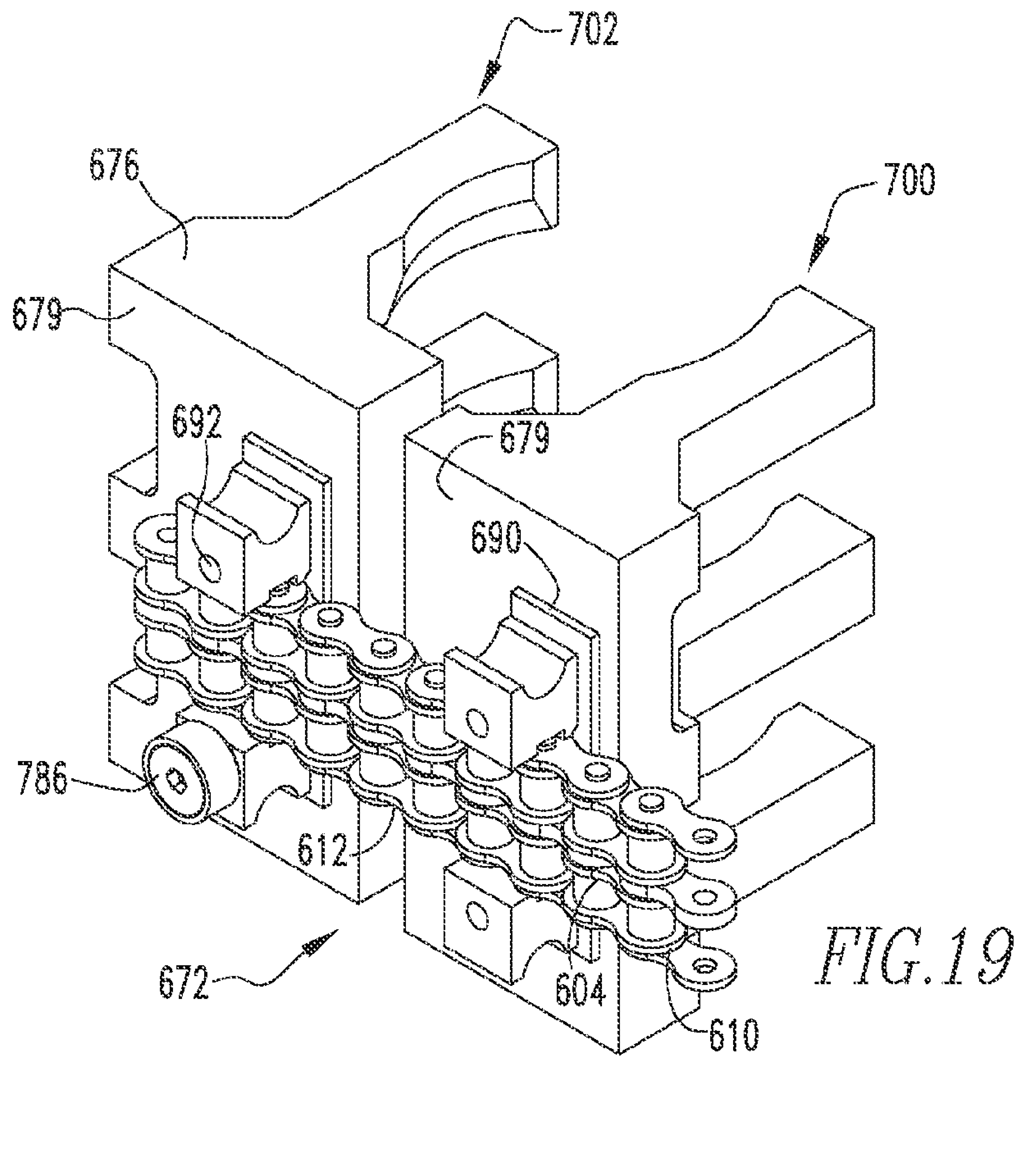
700

FIG.18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610

FIG.19

OPERATING MECHANISM FOR A VERTICALLY ORIENTED BODYMAKER

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Patent Application Ser. No. 61/777,190, filed Mar. 12, 2013 entitled OPERATING MECHANISM FOR A VERTICALLY ORIENTED BODYMAKER.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The disclosed concept relates generally to a can bodymaker and, more specifically, to an operating mechanism for a vertically oriented bodymaker.

2. Background Information

Generally, a can, such as but not limited to an aluminum can or steel can, begins as a sheet of metal from which a circular blank is cut. Hereinafter the can will be described as being made from aluminum, but it is understood that the selection of material is not limiting upon the claims. The blank is formed into a "cup." As used herein, a "cup" includes a bottom and a depending sidewall. Further, while cups and the resulting can bodies may have any cross-sectional shape, the most common cross-sectional shape is generally circular. Accordingly, while it is understood that the cups and the resulting can bodies may have any cross-sectional shape, the following description shall describe the cups, can bodies, punches, etc. as being generally circular.

The cup is fed into a bodymaker including a reciprocating ram and a number of dies. The elongated ram includes a punch at the distal end. A cup is disposed on the punch and passed through the dies which thin and elongate the cup. That is, on each forward stroke of the ram, a cup is initially positioned in front of the ram. The cup is disposed over the forward end of the ram, and more specifically on the punch located at the front end of the ram. The cup is then passed through the dies which further form the cup into a can body. The first die is the redraw die. That is, a cup has a diameter that is greater than the resulting can. A redraw die reshapes the cup so that the cup has a diameter generally the same as the resulting can body. The redraw die does not effectively thin the thickness of the cup sidewall. After passing through the redraw die, the ram moves through a tool pack having a number of ironing dies. As the cup passes through the ironing dies, the cup is elongated and the sidewall is thinned. More specifically, the die pack has multiple, spaced dies, each die having a substantially circular opening. Each die opening is slightly smaller than the next adjacent upstream die.

Thus, when the punch draws the cup through the first die, the redraw die, the aluminum cup is deformed over the substantially cylindrical punch. As the cup moves through the redraw die, the diameter of the cup, i.e., the diameter of the bottom of the cup, is reduced. Because the openings in the subsequent dies in the die pack each have a smaller inner diameter, i.e., a smaller opening, the aluminum cup, and more specifically the sidewall of the cup, is thinned as the ram moves the aluminum through the rest of the die pack. The thinning of the cup also elongates the cup.

Further, the distal end of the punch is concave. At the maximum extension of the ram is a "domer." The domer has a generally convex dome and a shaped perimeter. As the ram reaches its maximum extension, the bottom of the cup engages the domer. The bottom of the cup is deformed into a dome and the bottom perimeter of the cup is shaped as desired; typically angled inwardly so as to increase the strength of the can body and to allow for the resulting cans to be stacked. After the cup passes through the final ironing die and contacts the domer, it is a can body.

On the return stroke, the can body is removed from the punch. That is, as the ram moves backwardly through the tool pack, the can body contacts a stationary stripper which prevents the can body from being pulled backward into the tool pack and, in effect, removes the can body from the punch. In addition to the stripper, a short blast of air may be introduced through the inside of the punch to aid in can body removal. After the ram moves back to an initial position, a new cup is positioned in front of the ram and the cycle repeats. Following additional finishing operations, e.g., trimming, washing, printing, etc., the can body is sent to a filler which fills the can body with product. A top is then coupled to, and sealed against, the can body, thereby completing the can.

The ram and the die pack are typically oriented generally horizontally. That is, the longitudinal axis of the ram and the axis of the tool pack extends generally horizontally. In this orientation certain components of the bodymaker may be of a relatively simple construction. For example, a cup feeder, i.e., the device that positions cups in the path of ram travel, may rely, in part, on gravity to position a cup on a cup locator for further processing. Throughout this process the cup in the conventional cup feed mechanism is oriented with its axis in a horizontal plane. It is constrained on the sides by guide rails and on both ends by guide plates. When the cup is resting in the cup locator there is an opening present in the open end guide plate to facilitate insertion of the redraw sleeve (a sleeve that clamps the cup against the redraw die and which is hollow to allow the ram to pass therethrough).

Similarly, with a ram traveling in a horizontal direction, the can body take-away device may rely upon gravity to deposit the can bodies on a conveyor. The conveyor consists of a continuously moving chain having a series of rubber "L" shaped attachments. This chain conveyor moves in an upward incline in order to ensure the cans rest in the "L" shaped attachments. The constantly moving conveyor chain is timed such that the fingers of the attachments meet the can at the point it is stripped from the punch and is free to be removed from the bodymaker.

A ram traveling in a horizontal direction, however, has disadvantages. For example, the ram body is a cantilevered body, being coupled at one end to a drive mechanism. In this configuration, the weight of the ram body causes the ram body to droop. This droop may cause a mis-alignment between the ram and the tool pack. This mis-alignment may change over the course of a day, e.g., the ram body may heat up due to use thereby changing the characteristics of the ram which, in turn, change the alignment of the ram. Thus, there is not a simple solution such as repositioning the dies in the tool pack. The ram droop further causes quality problems in the forming of cans by making it difficult to maintain even wall thicknesses. The ram droop also may cause problems when the ram retracts. More specifically, the back side of the punch may contact the ironing dies resulting in abnormal wear to the dies. The ram droop can be mitigated to some degree by making the ram larger in diameter and making the assembly lighter but the tendency to droop will still be evident and using a larger diameter ram would not work when making a small diameter can. Further problems with a conventional bodymaker with the horizontal layout is that it has a relatively large footprint and all bodymakers made to date can only produce one can per cycle per machine. That is, for each revolution of the ram drive mechanism, a single can body is produced. This requires a plant operator to have a large number of machines to meet desired production quotas. Some of these disadvantages may be addressed by utilizing a ram that travels over a generally vertical path.

There is, therefore, a need for a bodymaker wherein the ram does not travel in a direction wherein the ram body may droop. There is a further need for a bodymaker that produces more than one can body per cycle.

SUMMARY OF THE INVENTION

These needs, and others, are addressed by the disclosed and claimed device which provides for a can bodymaker including two rams that travel over a generally vertical path. The bodymaker includes a housing assembly and an operating mechanism structured to move a number of ram assemblies over a vertical path of travel. The operating mechanism includes a crankshaft, a motor, a link assembly, and a number of ram assemblies. The crankshaft is rotatably coupled to the housing assembly and includes a number of pairs of crankpin journals. The motor is operatively coupled to the crankshaft. The link assembly includes a number of links. Each ram assembly includes an elongated ram body, each ram body structured to move over a ram path. Links from the link assembly extend between, and movably couple, each crankshaft crankpin journal to a ram body.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the disclosed concept can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

FIG. **1** is an isometric front view of a bodymaker.

FIG. **2** is an isometric rear view of a bodymaker.

FIG. **3** is a side cross-sectional view of a cup feeder assembly.

FIG. **4** is a detail side cross-sectional view of a cup feeder assembly.

FIG. **5** is a top view of a cup feeder in a first position.

FIG. **6** is a top view of a cup feeder in a second position.

FIG. **7** is a top view of a cup feeder in a third position.

FIG. **8** is a top, partial cross-sectional view of a cup feeder in a fourth position.

FIG. **9** is a detail isometric view of a crankshaft, link assembly and ram assembly.

FIG. **10** is an isometric view of a tool pack.

FIG. **11** is a partially exploded isometric view of a tool pack.

FIG. **12** is a cross-sectional view of a tool pack. FIG. **12**A is a detail view of a spray outlet.

FIG. **13** is a front view of a can body take-away assembly.

FIG. **14** is a cross-sectional side view of a can body take-away assembly.

FIG. **15** is a top view of a can body take-away assembly.

FIG. **16** is a detail cross-sectional side view of a can body take-away assembly.

FIG. **17** is a front view of a can body take-away assembly with the ram in a different position.

FIG. **18** is a front detail isometric view of a gripping assembly.

FIG. **19** is a rear detail isometric view of a gripping assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the singular form of "a," "an," and "the" include plural references unless the context clearly dictates otherwise. As used herein, the term "number," or "a number," shall mean one or an integer greater than one (i.e., a plurality).

As used herein, "coupled" means a link between two or more elements, whether direct or indirect, so long as a link occurs. An object resting on another object held in place only by gravity is not "coupled" to the lower object unless the upper object is otherwise maintained substantially in place. That is, for example, a book on a table is not coupled thereto, but a book glued to a table is coupled thereto.

As used herein, "directly coupled" means that two elements are directly in contact with each other.

As used herein, "fixedly coupled" or "fixed" means that two components are coupled so as to move as one while maintaining a constant orientation relative to each other. Similarly, two or more elements disposed in a "fixed relationship" means that two components maintain a substantially constant orientation relative to each other.

As used herein, the word "unitary" means a component is created as a single piece or unit. That is, a component that includes pieces that are created separately and then coupled together as a unit is not a "unitary" component or body.

As used herein, "associated" means that the identified components are related to each other, contact each other, and/or interact with each other. For example, an automobile has four tires and four hubs, each hub is "associated" with a specific tire.

As used herein, "engage," when used in reference to gears or other components having teeth, means that the teeth of the gears interface with each other and the rotation of one gear causes the other gear or other component to rotate/move as well. As used herein, "engage," when used in reference to components not having teeth means that the components are biased against each other.

Directional phrases used herein, such as, for example and without limitation, top, bottom, left, right, upper, lower, front, back, and derivatives thereof, relate to the orientation of the elements shown in the drawings and are not limiting upon the claims unless expressly recited therein.

As used herein, "correspond" indicates that two structural components are similar in size, shape or function. With reference to one component being inserted into another component or into an opening in the other component, "corresponding" means components are sized to engage or contact each other with a minimum amount of friction. Thus, an opening which corresponds to a member is sized slightly larger than the member so that the member can pass through the opening with a minimum amount of friction. This definition is modified if the two components are said to fit "snugly" together. In that situation, the difference between the size of the components is even smaller whereby the amount of friction increases. If one or more components are resilient, a "snugly corresponding" shape may include one component, e.g., the component defining the opening being smaller than the component inserted therein. Further, as used herein, "loosely correspond" means that a slot or opening is sized to be larger than an element disposed therein. This means that the increased size of the slot or opening is intentional and is more than a manufacturing tolerance.

As used herein, "at" means on or near.

A vertical bodymaker **10**, shown in FIGS. **1** and **2**, is structured to convert a cup **1** (FIG. **3**) into a can body **2** (FIG. **16**). A cup **1** includes a generally planar bottom **3** and a depending sidewall **4**, as shown in FIG. **3**. The vertical bodymaker **10**, i.e., a bodymaker wherein a number of rams travel in generally vertical orientation, includes a housing assembly **11**, a number of cup feed assemblies **12** (shown best in FIG. **2**), an operating mechanism **14**, a number of vertical tool packs **16**, i.e., a tool pack wherein the axis of the circular dies extends generally vertically, and a number of take-away assemblies **18**. As will be described below, the vertical bodymaker **10** may include at least two rams **250** and is able to process two cups **1** per cycle. As such, as shown, the vertical bodymaker **10** includes at least two of such components, such as the cup feed assembly **12**, the vertical tool pack **16**, and the take-away assembly **18**. Unless otherwise noted, the following description shall describe one of each component. It is understood, however, that the components include substantially similar elements and the description of one component is applicable to any similar component. It is, noted that some components are mirror images of each other, e.g., one take-away assembly **18** ejects the can bodies **2** to the left side of vertical bodymaker **10** and the other take-away assembly **18** ejects the can bodies **2** to the right side of vertical bodymaker **10**.

Generally, the housing assembly **11**, which, as used herein, includes a frame assembly (not shown), supports the operating mechanism **14** with a number of rams **250** extending in, and reciprocating in, a generally vertical direction. That is, the housing assembly **11** includes a number of ram paths **13** (FIG. **9**), i.e., a path of travel for a ram **250** and alternatively identified as a "ram **250** path of travel **13**." There is one ram path **13** for each ram **250**. In an exemplary embodiment, the cup feed assemblies **12**, the vertical tool packs **16**, and the take-away assemblies **18** are coupled to a housing assembly upper end **19**, i.e., generally above the operating mechanism **14** and rams **250**. In another embodiment, not shown, the positions of the components are generally reversed, i.e., the cup feed assemblies **12**, the vertical tool packs **16**, and the take-away assemblies **18** are coupled to the lower end of the housing assembly **11**. The cup feed assembly **12** is provided with a number of cups **1** which are individually fed to the vertical tool packs **16**. A ram **250** picks up the cup **1** and moves the cup through the vertical tool pack **16** to form a can body **2**. At the top of the ram's **250** stroke, the can body **2** is ejected from the ram **250** and collected by a take-away assembly **18**. The take-away assembly **18** moves the can body **2** away from the ram **250** and reorients the can body **2** to a horizontal orientation so that the can body **2** may be transported by traditional conveyors or other conveyors (not shown).

As shown in FIGS. **3-8**, the cup feed assembly **12** includes a chute assembly **20**, a cup locator **70** (FIGS. **5-8**), and a rotatable feeder disk assembly **80** (FIGS. **5-8**). In another embodiment, not shown, the cup feed assembly **12** further includes a cup stop (not shown). A cup stop is a pneumatically controlled device that starts and stops the flow of the cups **1** into the cup feed assembly **12** when there are interruptions in upstream or downstream processes. The chute assembly **20** includes a feeder chute **22** and a transfer chute **40**. The feeder chute **22** has a hollow body **24** defining an enclosed space **26**. The enclosed space **26** has a cross-sectional area corresponding to a cup **1**. That is, the enclosed space **26** cross-sectional area is slightly larger than a cup **1** so that a cup **1** may move freely therethrough. The feeder chute **22** includes an inlet end **28**, a medial portion **30** and an outlet end **32** (FIG. **3**). The feeder chute inlet end **28** extends generally vertically. The feeder chute medial portion **30** is arcuate and bends about ninety degrees so that feeder chute outlet end **32** extends generally horizontally. In this configuration, cups **1** may be introduced into the feeder chute inlet end **28** and fall, due to gravity, toward feeder chute outlet end **32**. The weight of cups **1** in the feeder chute inlet end **28** will further bias the cups **1** in the feeder chute medial portion **30** and feeder chute outlet end **32** toward the transfer chute **40**, described below. The feeder chute outlet end **32** includes a support surface **34**. The feeder chute outlet end support surface **34** extends generally horizontally. The cups **1** are oriented in the feeder chute **22** so that, when the cups **1** are in the feeder chute outlet end **32**, the cup bottom **3** is disposed above the depending sidewall **4**. That is, the cup **1** is inverted and opens downwardly.

The feeder chute **22** is coupled to a transfer chute **40**. More specifically, the transfer chute **40** includes a first end **42**, a medial portion **43**, and a second end **44**. The transfer chute **40** is generally arcuate and extends generally horizontally. The transfer chute first end **42** is in communication with feeder chute outlet end **32**. That is, as used herein, two or more chutes "in communication" with each other means than an object in one chute may pass into another chute. In one embodiment, shown in FIGS. **3** and **4**, the transfer chute **40** includes an upper member **50**, a lower member **52**, an inner first side member **54** (FIGS. **5-8**), and an outer second side member **56** (FIGS. **5-8**). The transfer chute lower member **52** is generally planar and extends horizontally. The transfer chute lower member **52** may include slots or other openings (not shown) that are generally smaller than the cups **1**. The transfer chute first side member **54** includes a slot **58** structured to allow feeder disk **81**, discussed below, to pass therethrough. The transfer chute first and second side members **54**, **56** define generally vertical guide surfaces **60**, **62**. That is, in an exemplary embodiment, transfer chute first and second side members **54**, **56** are an inner guide rail **64** and an outer guide rail **66**. The inner guide rail **64** and outer guide rail **66** are spaced slightly larger than the diameter of a cup **1**.

As shown best in FIGS. **5-8**, the transfer chute first end **42** and transfer chute medial portion **43** are defined by the transfer chute first and second side members **54**, **56** and transfer chute lower member **52**. The transfer chute first end **42** and transfer chute medial portion **43** are generally arcuate and have about the same center as the feeder disk **81**. Transfer chute second end **44** is also, in one embodiment, arcuate, but curves away from the center of the feeder disk **81**. The cup locator **70** is disposed at the transfer chute second end **44**. The cup locator **70** is an arcuate member **72** having a diameter corresponding, and in one embodiment snuggly corresponding, to the diameter of a cup **1**. That is, cup locator **70** defines a substantially vertical arcuate surface **74**. Thus, the cup locator **70** further defines a holding space **76**. The holding space **76** is in communication with the transfer chute second end **44**. While there may be a gap, there is a generally smooth transition between inner guide rail **64** and cup locator **70**. That is, the generally vertical surfaces defining the inner guide rail **64** and the inner side of cup locator **70** are generally aligned.

Before discussing other features of the transfer chute second end **44** it is noted that the ram **250** passes generally vertically through cup locator **70** and transfer chute second end **44**. Thus, cup locator **70** and transfer chute second end **44** does not have a horizontal surface extending over the ram **250** path of travel **13**. That is, the transfer chute upper member **50** and a lower member **52** do not extend over the cup locator **70** and transfer chute second end **44**. Put another way, at the ram **250** path of travel **13**, the transfer chute second end **44** is defined only by generally vertical guide surfaces. In reference to inner guide rail **64** and outer guide rail **66**, the inner guide rail **64** and the outer guide rail **66** do not have a horizontal member therebetween at the transfer chute second end **44**. In reference to the transfer chute second end **44**, the phrase "horizontal member" is not limited to planar horizontal members and includes arcuate members having a horizontal portion.

Because the transfer chute second end **44** does not include horizontal surfaces at the ram **250** path of travel **13**, another construct is used to support the cups **1** when the cups are disposed in the transfer chute second end **44** and cup locator **70**. This construct includes a number of biasing devices **100**, **102**. Before describing biasing devices **100**, **102**, the rotatable feeder disk assembly **80** will be described.

Rotatable feeder disk assembly **80** includes a motor (not shown) and a feeder disk **81**. Feeder disk **81** includes a disk body **82**. The feeder disk assembly motor, in one embodiment, is a constant speed motor. In another embodiment, the feeder disk assembly motor is a variable speed servo-motor. The feeder disk assembly motor has a rotating output shaft (not shown) that is coupled to the disk body **82** and structured to rotate the feeder disk body **82**. The feeder disk body **82** is rotatably coupled to the housing assembly **11**. The feeder disk body **82** includes a circumferential surface **84**. The circumferential surface **84** includes a first portion **86**, a second portion **88**, and a third portion **90**. The circumferential surface first portion **86** has a generally constant radius. In one embodiment, the circumferential surface first portion **86** defines a cutout **92** (FIG. **8**) having a reduced radius. As discussed below, an arcuate guide rail **120** is disposed in the first portion cutout **92** thereby providing a generally constant radius. The circumferential surface second portion **88** has a reducing radius and, in an exemplary embodiment, a constant spiral radius, i.e., reducing at a constant rate. The circumferential surface third portion **90** is a pocket **94**. The pocket **94** defines a generally arcuate surface **96** that increases the radius of the disk body **82** from the minimum circumferential surface second portion **88** radius to the circumferential surface first portion **86** radius. The curvature of the pocket arcuate surface **96** generally corresponds to the curvature of a cup **1**.

The feeder disk body **82** is rotatably coupled to the housing assembly **11** adjacent to the transfer chute first side member slot **58** and positioned so that, as the feeder disk body **82** extends partially into the transfer chute **40** via transfer chute first side member slot **58**. The feeder disk body **82** rotates in a generally horizontal plane. The feeder disk body pocket **94** faces forward as the feeder disk body **82** rotates. As set forth immediately below, the feeder disk body **82** is structured to move a cup **1** from the transfer chute first end **42**, over the transfer chute medial portion **43**, and into the transfer chute second end **44** and cup locator **70**.

That is, as noted above, gravity, and the weight of cups **1** in the feeder chute inlet end **28** bias the cups **1** in the feeder chute medial portion **30** and feeder chute outlet end **32** toward the transfer chute **40**. As the feeder disk body pocket **94** rotates past transfer chute first end **42**, a cup **1** is disposed in the feeder disk body pocket **94** and moved over the transfer chute medial portion **43**. At this time, the cup **1** behind the cup **1** (hereinafter "the second cup") in the feeder disk body pocket **94** is biased, initially, against the circumferential surface first portion **86**. As the circumferential surface first portion **86** is a generally constant radius, the second cup does not move forward into the transfer chute **40**. As feeder disk body **82** continues to rotate, the second cup is biased against circumferential surface second portion **88**. As the circumferential surface second portion **88** has a reducing radius, the second cup is moved into the transfer chute **40**. When the feeder disk body pocket **94** again rotates to the transfer chute first end **42**, the second cup **1** will be in a position to be moved by the feeder disk body pocket **94**.

The cup **1** in the feeder disk body pocket **94** is moved over the transfer chute medial portion **43**, generally moving in an arcuate path about the center of feeder disk body **82**. As noted above, the transfer chute second end **44** curves away from the center of the feeder disk body **82**. Thus, as the cup is moved into the transfer chute second end **44**, the curvature of the transfer chute second end **44** causes the cup **1** to be moved out of the feeder disk body pocket **94**. As shown in FIG. **6**, the tip of the feeder disk body pocket **94** maintains contact with the cup **1** as the cup **1** moves over the upstream portion of transfer chute second end **44**. That is, the "nose" of the feeder disk body pocket **94** pushes the cup **1** through the upstream portion of transfer chute second end **44**. It is noted that, unlike a vertically oriented cup feeder which relied upon gravity to move a cup through a transfer chute, in this embodiment, the exclusive force moving the cup **1** through the transfer chute **40** is the force provided by the rotatable feeder disk assembly **80**. That is, as used herein, the phrase "the exclusive force moving the cup through the transfer chute is the force provided by the rotatable feeder disk assembly," means that gravity is not a force acting on a cup so as to move the cup through a transfer chute.

As shown in FIGS. **5**-**8**, as the cup **1** is moved fully into the transfer chute second end **44** and cup locator **70**, the nose of feeder disk body pocket **94** moves past cup **1** leaving circumferential surface first portion **86** in contact with the cup **1**. Thus, when the cup **1** is disposed at the transfer chute second end **44** and cup locator **70**, the cup **1** is contacted by circumferential surface first portion **86** and the transfer chute second end **44**. As noted above, the transfer chute second end **44** and cup locator **70** do not include a horizontal surface at the ram **250** path of travel **13**. Thus, the cup **1** is supported by the biasing devices **100**, **102**, which are disposed at circumferential surface first portion **86** and the transfer chute second end **44**.

A first biasing device **100** is disposed at transfer chute second end **44** and, in one embodiment at the outer guide rail **66** at transfer chute second end **44**. The first biasing device **100** includes a number of resilient members **104**. The resilient members **104** extend into transfer chute second end **44**. More specifically, in one exemplary embodiment, resilient members **104** are elongated members having a proximal end **108** and a distal end **110**. The resilient member proximal ends **108** are disposed adjacent to, and coupled to, the outer guide rail **66**. The resilient member distal ends **110** extend into the transfer chute second end **44** and define a generally vertical surface **111**. The resilient member vertical surface **111** extends substantially parallel to the inner guide rail **64**. The resilient members **104** may be part of a brush assembly **112**. That is, first biasing device **100** may be a brush assembly **112** including a number of bristles **114**. In this configuration, the first biasing device **100** is structured to maintain a cup **1** in the holding space **76**.

In operation, and as shown in FIGS. **5**-**8**, the first biasing device **100** biases a cup **1** against the opposing guide rail, the inner guide rail **64** as shown. That is, as the nose of the feeder disk body pocket **94** pushes the cup **1** through the upstream portion of transfer chute second end **44** and moves the cup **1** over the portion of transfer chute **40** lacking a horizontal surface, the bias of the first biasing device **100** maintains the cup **1** in a generally horizontal orientation within transfer chute **40**.

The second biasing device **102** is disposed on feeder disk body **82**. In one embodiment, the second biasing device **102** includes an arcuate guide rail **120** that is disposed in the first portion cutout **92**. The arcuate guide rail **120** has an outer radius that is substantially similar to the radius of the circumferential surface first portion **86**. The arcuate guide rail **120** is movably coupled to the feeder disk body **82** by biasing member **122**, as shown, springs **124**. The springs **124** have a longitudinal axis and, in an exemplary embodiment, the longitudinal axes of the springs **124** are generally parallel. The biasing member **122** biases the arcuate guide rail **120** outwardly. The range of motion of the arcuate guide rail **120** may be limited by a slot and pin coupling **126**. That is, pins extending from feeder disk body **82** pass through generally radial slots in the arcuate guide rail **120** as shown in FIG. **8**. In another embodiment, the arcuate guide rail **120** is a resilient body **121** or includes a resilient outer surface. In this embodiment, the resilient body is the biasing member **122**.

In this configuration, and as shown in FIG. **8**, the arcuate guide rail **120** is biased generally radially outwardly. Thus, when the cup **1** is moving into, and when the cup **1** is disposed in, the transfer chute second end **44** and cup locator **70**, the second biasing device **102** biases the cup **1** toward the cup locator **70**. Thus, a cup **1** in a horizontal orientation is maintained in the cup locator **70** even though the cup locator **70**, as well as the transfer chute second end **44**, does not include a horizontal surface at the ram **250** path of travel **13** to support the cup **1**. Further, and as described below, the cup locator **70**, as well as the transfer chute second end **44**, are disposed below and adjacent to the redraw mechanism **270**. A cup **1** in this position may be picked up by a ram body **252** (described below), and passed through the tool pack **16**.

As shown in FIGS. **1** and **9**, the operating mechanism **14** includes a crankshaft **150**, an operating mechanism motor **152** (FIG. **2**), a link assembly **180** and a ram assembly **250**. Generally, the crankshaft **150** movably supports a number of ram assemblies **250** (also referred to as "rams **250**"). The crankshaft **150** causes the ram assemblies **250** to reciprocate along a generally vertical ram path **13**. In an exemplary embodiment, the ram assemblies **250** are disposed in pairs wherein the ram assemblies **250** in a pair move in generally opposite directions. That is, as one ram assembly **250** is moving upwardly, the other ram assembly **250** is moving downwardly. The operating mechanism motor **152** drives the crankshaft **150**. The link assembly **180** couples the crankshaft **150** to the ram assemblies **250** and, in an exemplary embodiment, reduces stress on the ram assemblies **250**. A ram assembly **250**, as used herein, may include a redraw mechanism **270**. Alternatively, a redraw mechanism **270** may be considered an independent component or as part of the tool pack **16**, but in the following description the redraw mechanism **270** is considered part of a ram assembly **250**.

As shown in FIG. **1**, the crankshaft **150** is rotatably coupled to the housing assembly **11**. The operating mechanism motor **152** drives the crankshaft **150**. In an exemplary embodiment, operating mechanism motor **152** is an AC induction motor driven by a variable frequency drive. As shown, the operating mechanism motor **152** includes a rotating output shaft **154** that is operatively coupled to the crankshaft **150**. As used herein, and in connection with a motor, "operatively coupled" means that the element operatively coupled to the motor is coupled so as to respond to the motion created by the motor's output shaft; the coupling may be direct, such as, but not limited to, output shaft coupled directly to an axle, or, indirect such as, but not limited to, an output shaft coupled via a belt to an axle. As shown in FIG. **2**, the operating mechanism motor **152** is operatively coupled, via a belt **156**, to a clutch/brake assembly **158**. The clutch/brake assembly **158** is coupled to crankshaft **150** and, more specifically, to a shaft **160** of the crankshaft **150**.

As shown in FIG. **9**, the crankshaft **150** includes the shaft **160** as well as a number of offset crankpins **162**. Each crankpin **162** has an outer surface (not shown) that acts as a journal. As such, each crankpin **162** is hereinafter identified as a crankpin journal **164**. In an exemplary embodiment, the crankpin journals **164** are provided in pairs and, as shown, the following description will address a crankshaft **150** including two crankpin journals **164**. It is understood, however, that the claimed concept is not limited to two crankpin journals **164**.

Each crankpin journal **164** is maintained in a position offset from the axis of the shaft **160** by a yoke **166**. Each yoke **166** includes two elongated yoke members **170**, **172**. Each yoke member **170**, **172** includes a first end **174** and a second end **176**. Each yoke first end **174** includes a shaft opening **175** and each yoke second end **176** includes a distal opening **177**, i.e., an opening that is distal to the axis of rotation of the crankshaft **150**. Shaft **160** is fixed to each yoke member **170**, **172** at a shaft opening **175**. Each crankpin journal **164** is fixed to the yoke members **170**, **172** between opposed distal openings **177**. Each yoke member **170**, **172** may include a counterbalance such as, but not limited to, a lobe **178**.

Further, as shown, when a crankshaft **150** includes two crankpin journals **164**, the crankpin journals **164** are disposed substantially on opposite sides of shaft **160**. As used herein, crankpin journals **164** disposed substantially on opposite sides of shaft **160** shall be identified as "opposing crankpin journals." In this configuration, and when a linkage **184** (described below) is coupled to each crankpin journal **164**, the linkages **184** will move in opposition to each other. That is, for example, if one linkage **184** is moving upwardly, the other linkage **184** will be moving downwardly.

Each crankpin journal **164** is one component of a rotational coupling. As used herein, a "rotational coupling" is a coupling linking two components that allows the components to rotate relative to each other. A "rotational coupling" may include, but is not limited to, a substantially circular opening in one, or both components, and a substantially circular pin corresponding to, and passing through, the opening. For example, each crankpin journal **164** is a substantially circular pin that passes through a pivot rod first end opening (described below). It is understood, however, that a "rotational coupling" may have an alternate configuration such as, but not limited to, a substantially circular lug extending from one component into a substantially circular opening in the other component. Further, a rotational coupling **181**, in an exemplary embodiment, includes a bearing or other friction reducing device. All rotational couplings shall be identified by reference number **181** and shall be preceded by a description of its location on another component.

The link assembly **180** includes a number of links **182** wherein the links **182** are coupled to form a linkage **184**. It is understood that there is one linkage **184** for each ram assembly **250**. As such, the following description will address a single linkage **184**; it is understood that each linkage **184** is substantially similar.

In one exemplary embodiment, the link assembly **180** includes at least one rotational coupling **181** disposed between the crankshaft **150** and a ram body **252**. For example, in one exemplary embodiment, not shown, the link assembly **180** includes a connecting rod **190** and a slider **240**. The slider **240** is discussed in detail below. The connecting rod **190** is an elongated body **191** that includes a first end **192** and a second end **194**. The connecting rod first end **192** includes a rotational coupling **181** and the connecting rod second end **194** also includes a rotational coupling **181**. The connecting rod first end rotational coupling **181** is rotatably coupled to a crankpin journal **164**. The connecting rod second end rotational coupling **181** is rotatably coupled to a slider **240**, and more specifically a slider body **242** which is coupled to a ram body **252**.

In the embodiment described above, rotation of the crankshaft **150** causes a ram body **252** to reciprocate along a generally vertical axis, as described below. With a single link, however, the conversion of rotational motion to linear motion applies stress to the various components, such as, but not limited to high normal slide forces against the slide guidance rails (slider channels). Thus, in another exemplary embodiment, shown in FIG. **9**, each linkage **184** further includes a swing arm **200** and a pivot rod **210**. The swing arm **200** includes a pivot member **202** and a yoke **204**. The swing arm yoke **204** extends generally radially from swing arm pivot member **202**. That is, the swing arm yoke **204** has a first end **206** that is coupled to the swing arm pivot member **202**. Further, the swing arm yoke **204** has a second end **208** that includes a rotational coupling **181**. The swing arm pivot member **202** is rotatably coupled to the housing assembly **11**.

The pivot rod **210** is an elongated body **211** that includes a first end **212** and a second end **214**. The pivot rod first end **212** includes a rotational coupling **181**. The pivot rod second end **214** includes a rotational coupling **181**. When assembled, the linkage **184** includes the connecting rod first end rotational coupling **181** rotatably coupled, and in an exemplary embodiment directly rotatably coupled, to a crankpin journal **164**. The connecting rod second end **194** is rotatably coupled, and in an exemplary embodiment, directly rotatably coupled, to the pivot rod first end rotational coupling **181**. The pivot rod second end rotational coupling **181** is rotatably coupled to a slider **240**, and more specifically a slider body **242** which is coupled to a ram body **252**. The swing arm second end rotational coupling **181** is rotatably coupled to the connecting rod second end rotational coupling **181**. In this configuration, the swing arm **200** limits the range of motion of the linkage **184** thereby reducing stress on the components thereof. For example, limiting the range of motion of the linkage **184** significantly reduces the normal slide force against the slide guidance rails (slider channels).

The housing assembly **11** includes a number of ram guides **230** (FIG. **1**) and slider channels **232** (FIG. **1**). Each ram guide **230** defines an opening (not shown). If there are more than two ram guides **230** for a single ram assembly **250**, the ram guide openings are disposed on a generally vertical line. The slider channels **232** are disposed in opposed pairs and, as shown, include members having U-shaped cross-sections. The slider channels **232** are also disposed generally vertically and are positioned about the generally vertical line passing through the ram guides **230**. In this configuration, the housing assembly **11**, and more specifically the ram guides **230** and slider channels **232**, defines paths of travel that extend generally vertically. That is, the ram assemblies **250** are structured to reciprocate over the ram paths.

The slider **240** includes a body **242**, as shown a generally rectangular body, including a rotational coupling **181**. The slider body **242** has an upper surface **244** and two lateral sides **246**, **248**. The slider body lateral sides **246**, **248** are sized to correspond to the slider channels **232**. The slider body **242** is disposed in the slider channels **232** and moves between a first lower position in the slider channels **232** and a second upper position in the slider channels **232**. Thus, the slider body **242** reciprocates generally vertically. As noted above, the pivot rod second end rotational coupling **181** is rotatably coupled to the slider body **242**.

As with the linkage **184**, the ram assemblies **250** are substantially similar and a single ram assembly **250** will be described. The ram assembly **250** includes an elongated ram body **252** and a punch **254**. The ram assembly **250**, and more specifically the ram body **252**, has a longitudinal axis **251** that extends generally vertically. As is known, the ram assembly **250** may include other components, e.g., a pneumatic system (not shown) structured to eject a can body **2** from the punch **254**; such components are not, however, relevant to the presently disclosed concept. When disposed in a vertical orientation, the ram body **252** includes a lower, first end **256** and an upper, second end **258**. The ram body first end **256** is coupled to, and in one embodiment fixed to, the slider body upper surface **244**. The punch **254** is coupled to, and in one embodiment fixed to, the ram body second end **258**. In this configuration, the ram body **252**, as well as the punch **254**, reciprocate over a generally vertical path. That is, each ram assembly **250**, and more specifically each ram body **252**, moves between a retracted, lower first position and an extended, upper second position. The path over which each ram assembly **250** moves is the "path of travel" or "path." Further, each ram assembly **250** has a "forward stroke" when moving from the first position to the second position and a "return stroke" when moving from the second position to the first position. As discussed below, each ram assembly **250**, and more specifically each punch **254**, is structured to pick up a cup **1** and move the cup **1** through the tool pack **16** during the forward stroke. Further, as discussed above, each ram body **252** is coupled to one of two linkages **184** in a pair. As further described above, the linkages **184** are coupled to opposing crankpin journals **164**. The configuration wherein the linkages **184** are coupled to opposing crankpin journals **164** cause the sliders **240** to move in opposite directions.

Thus, if the number of ram assemblies **250** is two, there is a first ram assembly **250**A and a second ram assembly **250**B. When the first ram assembly **250**A is in the first position, the second ram assembly **250**B is substantially in the second position, and, when the first ram assembly **250**A is in the second position, the second ram assembly **250**B is substantially in the first position. When the first ram assembly **250**A is moving forward, i.e., during the forward stroke, the second ram assembly **250**B is moving backward, i.e., during the return stroke.

As with the linkage **184**, the redraw mechanism **270** is substantially similar and a single redraw mechanism **270** will be described. The redraw mechanism **270**, shown largely in FIG. **3**, includes a redraw die **271** and a clamping device **272**. In an exemplary embodiment wherein the redraw mechanism **270** is driven by the crankshaft **150**, the crankshaft **150** includes a number of redraw cams **274** (FIG. **9**) and the link assembly **180** includes a number of push rods **275** (FIG. **1**). As is known, the redraw die **271** defines a passage **278** corresponding to the size and shape of a ram body **252**. As described above, a cup feed assembly **12** positions a cup **1** below the redraw die **271** and above the redraw mechanism **270**. More specifically, the cup **1** is positioned so as to be aligned with the redraw die passage **278**. The redraw die clamping device **272**, in an exemplary embodiment, is a hollow sleeve **279**. The sleeve **279** has an outer diameter corresponding to a cup **1** inner diameter. The sleeve **279** further has an inner diameter corresponding to a punch **254** outer diameter. In operation, when a cup **1** is disposed below the redraw die **271**, the sleeve **279** moves upwardly into the cup **1** and biases, i.e., clamps, the cup **1** against the bottom of the redraw die **271**. The ram body **252** then moves through the sleeve **279** and picks up the cup **1** on the punch **254**. That is, the cup **1** is disposed over the punch **254** and moves with the punch **254**. As the punch **254** moves through the redraw die **271**, the shape of the cup **1** changes. More specifically, the diameter of the cup **1** is reduced to substantially correspond to the diameter of the punch **254**. This reshaping elongates the cup **1**, but does not effectively thin the cup sidewall **4**.

The redraw die clamping device **272** is actuated by the crankshaft **150**. That is, the sleeve **279** is movably coupled to the housing assembly **11** and is structured to move over a vertical path. The sleeve **279** is further coupled to a number of push rods **275**. As shown, a redraw link **276** may be an elongated rod **280** disposed in generally vertically oriented redraw link guides **282**, i.e., guide structures having vertically aligned openings. As shown, each sleeve **279** is coupled to two push rods **275** with the push rods **275** being disposed on opposite sides of the sleeve **279**. The lower end of each redraw link **276** engages the crankshaft **150** and more specifically a redraw cam **274**.

That is, as shown in FIG. **9**, a number of redraw cams **274** are fixed to the shaft **160** and rotate therewith. The redraw cams **274** have an outer cam surface **290**. The radius of the outer cam surface **290** is variable having a minimum radius and a maximum radius. The arc over which the minimum radius extends is greater than the arc over which the maximum radius extends. As the crankshaft **150** rotates, the lower end of each redraw link **276** moves over an outer cam surface **290**. When a redraw link **276** engages the minimum radius of an outer cam surface **290**, the sleeve **279** is in a retracted, first position and the cup feed assembly **12** may position a cup **1** below and adjacent to the redraw mechanism **270**. When a redraw link **276** engages the maximum radius of an outer cam surface **290**, the sleeve **279** is in an extended, second position and clamps the cup **1** against the redraw die **271** as described above. The elongated arc of the maximum radius of an outer cam surface **290** provides a dwell time for the redraw die clamping device **272** so that the cup remains clamped while the ram body **252** passes through the sleeve **279** and the cup body through the redraw die **271**. Thus, the rotation of the crankshaft **150** actuates each clamping device **272**.

The vertical tool pack **16** is shown in FIGS. **10-12**. For a bodymaker **10** wherein the ram assemblies **250** forward stroke is upward, each vertical tool pack **16** is coupled to the upper end of the housing assembly **11** and is generally aligned with one of the ram assemblies **250**. Each vertical tool pack **16** is substantially similar and only one will be described below. The vertical tool pack **16** includes a tool pack housing assembly **300**, a number of die spacers **400**, a number of dies **450**, and a compression device **470**. Generally, the die spacers **400** and the dies **450** each define a central passage **408**, **454**. The die spacer central passage **408** is larger than the cross-sectional area of the ram body **252**. Thus, a cup **1** disposed on the punch **254** passing through a die spacer **400** does not engage the die spacer **400**. Each die passage **454** closely corresponds to the ram body **252** so that a cup **1** disposed on the punch **254** passing through each die **450** is thinned and elongated. As is known, the downstream die passages are smaller than the upstream die passages so that the cup **1** is thinned and elongated by each die **450**. When the cup **1** passes through the tool pack **16** it is changed into a can body **2**.

As shown in FIG. **10**, the tool pack housing assembly **300** is shown as having a generally rectangular cross-section. It is understood that the tool pack housing assembly **300** may have any shape including a generally circular cross-section (not shown). It is further understood that descriptive words applicable to a tool pack housing assembly **300** having a generally rectangular cross-section are applicable to a tool pack housing assembly having other shapes. For example, in a tool pack housing assembly having a generally circular cross-section, the portion of the housing including a door and extending over an arc of about ninety degrees would be a front side. Similarly, the portions of a circular tool pack housing assembly extending over an arc of about ninety degrees and located adjacent to the front side would be the lateral sides, and so forth.

As shown in FIG. **10**, the tool pack housing assembly **300** includes an upper sidewall **302**, a lower sidewall **304**, a first lateral sidewall **306**, a second lateral sidewall **308**, a rear sidewall **310**, and a door **312**. In the exemplary embodiment the door **312** comprises, essentially, all of a front side. It is understood that in other embodiments, not shown, the door **312** may be less than the entire front side. The upper and lower sidewalls **302**, **304** each include a central opening **314**, **316**. In this configuration, the tool pack housing assembly **300** defines a passage **320** having a vertical axis. The tool pack housing assembly passage **320** includes an inner surface **322**. That is, each of the tool pack housing assembly elements has an inner surface **322**.

The tool pack housing assembly first lateral sidewall **306** and the tool pack housing assembly second lateral sidewall **308** each include a front surface **330**, **332**. The door **312** is structured to move between a first, open position, wherein the door **312** provides access to the tool pack housing assembly passage **320**, and a second, closed position, wherein the door **312** inner surface is disposed immediately adjacent the first lateral sidewall front surface **330** and the tool pack housing assembly second lateral sidewall front surface **332**. In an exemplary embodiment, door **312** is movably coupled to the tool pack housing assembly second lateral sidewall front surface **332** by a hinge assembly **334**.

The door **312** may include a latch assembly **340**. The latch assembly **340** includes a latch base **342** and a latch handle **344**. The latch handle **344** is movably coupled to the first lateral sidewall **306**. The latch base **342** is coupled to the door **312**. The latch handle **344** includes a cam member **346**. The latch handle **344** is structured to move between an open, first position, wherein said latch handle **344** does not engage the latch base **342**, and a closed, second position, wherein the latch handle cam member **346** engages the latch base **342**.

The door **312** has an inner surface **350**. The door **312** further includes a number of resilient bumpers **352**. Each bumper **352** is coupled to the door inner surface **352** and aligned with one of the dies **450** when the die **450** is disposed in the tool pack housing assembly **300**. Each bumper **352** has a thickness sufficient so that, when the door **312** is in the second position, each bumper **352** contacts one of the dies **450**. Thus, when the door **312** is in the second position, each bumper **352** contacts one of the dies **450** and biases the die **450** against the tool pack housing assembly rear sidewall **310**, thereby locking each die **450** in a substantially fixed orientation and location relative to the tool pack housing assembly **300**. As noted below, the dies **450** may include a circular outer surface **456**. The bumpers **352** include a distal surface **356** which is the surface opposite the bumper surface coupled to the door **312**. Each bumper distal surface **356** is, in an exemplary embodiment, concave and has a curvature corresponding to a die body outer surface **456**.

The tool pack housing assembly upper sidewall **302** includes a stripper bulkhead **360**. The stripper bulkhead **360** includes a stripper element **362** structured to remove the can body **2** from the punch **254** during the return, i.e., downward, portion of the ram body **252** stroke. The tool pack housing assembly lower sidewall **304** includes a cup feed bulkhead **370**. The cup feed bulkhead **370** includes a horizontally centering cavity **372** for the redraw die **271**. That is, the cup feed bulkhead horizontally centering cavity **372** is structured to horizontally center the redraw die **271** when the redraw die **271** is disposed therein. That is, the cup feed bulkhead horizontally centering cavity **372** is structured to position the redraw die **271** concentrically about the ram **250** path of travel **13**. Further, in an exemplary embodiment, each spacer **400**A, **400**B (discussed below) also includes a centering cavity **422** (discussed below) structured to position a supported die concentrically about the ram **250** path of travel **13**.

The tool pack housing assembly inner surface **322** defines a number of pairs of horizontal slots **380**. Each pair of horizontal slots **380** includes opposed slots **380'**, **380"** on the tool pack housing assembly first lateral sidewall **306** and the tool pack housing assembly second lateral sidewall **308**. Each slot **380'**, **380"** is sized to loosely correspond to the height of an associated die spacer **400**. That is, specific die spacers **400**A, **400**B (discussed below) have very different heights and are structured to be placed in a specific pair of slots **380**. As used herein, "associated" means that the identified elements are related to each other or are intended to be used together. For example, die spacer **400**A is a thinner die spacer and is intended to be placed in a thinner pair of slots **380**A. Thus, the height of the thinner pair of slots **380**A loosely corresponds to the height of an associated die spacer **400**A. Similarly, die spacer **400**B is a thicker die spacer and is intended to be placed in a thicker pair of slots **380**B. Thus, the height of the thicker pair of slots **380**B loosely corresponds to the height of an associated die spacer **400**B. It is further understood that the height of a specific pair of slots **380** does not loosely correspond to a die spacer **400** that is not "associated" with that specific pair of slots **380**. For example, the height of a thinner pair of slots **380**A does not loosely correspond to the height of a thicker die spacer **400**B.

In an exemplary embodiment, each pair of horizontal slots **380** has a height between about 0.040 inch and 0.050 inch greater than the die spacer **400** associated with that specific pair of horizontal slots. In another exemplary embodiment, each slot **380'**, **380"** in a specific pair of horizontal slots **380** has a height about 0.045 inch greater than the specific die spacer **400** associated with that specific pair of horizontal slots **380**. In an alternate exemplary embodiment, each pair of horizontal slots **380** has a height between about 0.025 inch and 0.040 inch greater than the die spacer **400** associated with that specific pair of horizontal slots. In another alternate exemplary embodiment, each slot **380'**, **380"** in a specific pair of horizontal slots **380** has a height about 0.03 inch greater than the specific die spacer **400** associated with that specific pair of horizontal slots **380**.

The number of die spacers **400** includes supported die spacers **402** and floating die spacers **404**. Supported die spacers **402** are those die spacers **400** that are supported by the tool pack housing assembly inner surface **322**. Floating die spacers **404** are spacers **400** disposed on dies **450** or other spacers **400**. Each die spacer **400** includes a body **406** defining a central passage **408**. Each die spacer central passage **408** is larger than the cross-sectional area of the punch **254**. Thus, the punch **254**, and a cup **1** disposed thereon, pass freely through the die spacers **400**. Each die spacer **400** has a height. The number of die spacers **400** and the number of dies **450** have a height, collectively, that loosely corresponds with the height of the cavity defined by the tool pack housing assembly **300**. The die spacers **400**, however, may have varying heights. Each supported die spacer **402** is associated with a specific pair of horizontal slots **380**. As noted above, and in an exemplary embodiment, a supported die spacer **402** may be a thinner supported die spacer **402**A or a thicker supported die spacer **402**B. As discussed below, each die spacer **400** may include a number of passages **490** which are part of a coolant system **480**.

Each supported die spacer **402** includes two lateral sides **410**, **412**. The supported die spacer lateral sides **410**, **412** are shaped to correspond to the shape of the tool pack housing assembly **300**. That is, as shown, when the tool pack housing assembly **300** is generally rectangular, the supported die spacer lateral sides **410**, **412** are generally parallel and straight. Each supported die spacer **402** has a door side **414**. The supported die spacer door side **414** includes a removal tool coupling **416**. That is, the removal tool coupling **416** is one element of a coupling that is structured to be coupled to a removal tool (not shown). In the exemplary embodiment shown in FIG. **11**, the removal tool coupling **416** is a notch in the supported die spacer door side **414**.

Each supported die spacer **402** includes an upper surface **420**. Each supported die spacer upper surface **420** includes a horizontally centering cavity **422** sized to correspond to an associated die **450**. As used herein, an "associated die" is the die **450** intended to be disposed on the associated supported die spacer **402**. The supported die spacer horizontally centering cavity **422** is structured to horizontally center a die **450** therein. That is, as noted above, the centering cavity **422** is structured to position a supported die **450** concentrically about the ram **250** path of travel **13**. In an alternate embodiment, not shown, the dies **450** are positioned by positioning rails (not shown).

In this configuration, the die spacers **400** may be easily moved into and out of the tool pack housing assembly **300**. For example, initially, the dies **450** associated with the specific supported die spacers **402** are disposed in the supported die spacer horizontally centering cavity **422**. If a floating die spacer **404** is required, the floating die spacer **404** may be placed on the relevant dies **450**. The supported die spacers **402** are then moved into the tool pack housing assembly **300** by placing the supported die spacers **402** in their associated pairs of slots **380**. As discussed below, the compression device **470** locks the dies **450** and die spacers **400** in place. When the compression device **470** is released, the dies **450** and die spacers **400** may be removed, e.g., by using the removal tool to pull the supported die spacers **402** from their slots **380**. Accordingly, because removal and replacement is easily accomplished, the number of dies **450** may include a first set of dies **440** having a first internal diameter (as discussed below) and a second set of dies **442** having a second internal diameter, wherein in one of the first set of dies **440** or the second set of dies **442** is disposed in the tool pack housing assembly **300**.

The dies **450** include a body **452** defining a central passage **454**. In an exemplary embodiment, the die bodies **452** have a generally circular outer surface **456**. The die central passage **454** has an internal diameter. Each die central passage **454** corresponds to the cross-sectional area, i.e., has a diameter that corresponds, to the punch **254**. More specifically, as discussed above, each die central passage **454** is slightly more narrow than the preceding die **450** (i.e., in the direction of travel of the ram assembly during the forward stroke). In this configuration, each die **450** thins the cup sidewall **4** and elongates the cup **1**. In an exemplary embodiment, the dies **450** are a generally torus shaped and have an outer diameter as well. The supported die spacer horizontally centering cavity **422** and the bumper distal surfaces **356** correspond to the shape of the die **450** outer surface. As noted above, the dies **450** and die spacers **400** are disposed in the tool pack housing assembly **300**.

The compression device **470** shown in FIG. **12**, is structured to provide axial compression to the stack of dies **450** and die spacers **400**. As shown, the compression device **470** is disposed at the lower end of the tool pack housing assembly **300**, i.e., at the tool pack housing assembly lower sidewall **304**. In this configuration, the compression device **470** axially biases the die spacers **400** by applying an upward force. Because, as noted above, the number of die spacers **400** and the number of dies **450** have a height, collectively, that loosely corresponds with the height of the cavity defined by the tool pack housing assembly **300**, applying an upwardly biasing force compresses the number of die spacers **400** and the number of dies **450**, thereby, effectively, locking the number of die spacers **400** and the number of dies **450** in place. It is further noted that, because the pairs of slots **380** have a height slightly greater than the height of the associated die spacer, the die spacers **400** do not directly engage, or otherwise apply bias to, the first lateral sidewall **306** or the second lateral sidewall **308**. That is, the bias created by the compression device **470** is applied, through the stack of die spacers **400** and dies **450**, to the upper sidewall **302**. The compression device **470** includes a lifting piston **472**. The lifting piston **472**, in an exemplary embodiment, has a torus shaped body **474**.

The tool pack housing assembly **300** and die spacers **400** include a coolant system **480**. That is, the coolant system **480** includes a number of passages that may be passages within specific components, such as, but not limited to, the rear sidewall **310** or a die spacer **400**, but may also be created by a gap between adjacent elements, e.g., a gap between a die **450** and a die spacer **400**. The coolant system **480** includes an inlet **482**, a distribution passage **484**, a number of die spacer manifolds **486**, a number of spray outlets **488**, a number of collection passages **490**, a drain passage **492**, and a trough **494**. The inlet **482** is disposed on the tool pack housing assembly **300**. The inlet **482** is coupled to, and in fluid communication with, a coolant source (not shown). The distribution passage **484** is disposed in the tool pack housing assembly **300**. As shown, the distribution passage **484** extends generally vertically, thereby providing access to the die spacers **400**. The distribution passage **484** is coupled to, and in fluid communication with, the inlet **482**. A number of die spacers **400**, and more specifically a number of supported die spacers **402**, include a die spacer manifold **486**. In an exemplary embodiment, a die spacer manifold **486** is a passage extending about the die spacer passage **408**. Each die spacer manifold **486** is coupled to, and in fluid communication with, the distribution passage **484**.

Each said die spacer **400** further includes a number of spray outlets **488**. Each spray outlet **488** is coupled to, and in fluid communication with, a die spacer manifold **486** as well as the die spacer passage **408**. Each spray outlet **488** is structured to spray a coolant into, and in an exemplary embodiment, at an upward angle into, the die spacer passage **408**. Each collection passage **490** has a first end **496** disposed adjacent to the tool pack housing assembly passage **320**. Each collection passage **490** is structured to collect fluid in the tool pack housing assembly passage **320**. In addition to the collection passage **490** a number of die spacers **400** include a collection reservoir **498**. The collection reservoir **498** is a cavity disposed about die spacer passage **408**. The collection reservoir **498** is coupled to, and in fluid communication with, a collection passage **490**. Each collection passage **490** is coupled to, and in fluid communication with, the drain passage **492**. The drain passage **492** is, coupled to, and in fluid communication with, the trough **494**. The trough **494** is an enclosed chamber disposed at the lower end of the tool pack housing assembly **300**. The trough **494** is further coupled to, and in fluid communication with, an external drain system (not shown). Thus, a coolant may be sprayed on the cup **1** and ram assembly **250** when the bodymaker **10** is in operation.

Further, as is known and shown in FIG. **13**, the bodymaker **10** may include a domer **500**. The domer has a convex die **502** disposed adjacent, but spaced from, the tool pack **16**. When the ram assembly **250** is in the second, extended position, the punch **254**, which includes a concave axial surface (not shown), is disposed immediately adjacent the domer **500**. In this configuration, the cup **1** contacts the domer **500** creating a concave cup bottom **3** and completes the transformation of the cup **1** to a can body **2**. At this point in the process, the can body **2** is supported by the ram assembly **250**. The cab body **2** is then stripped from the punch **254** when the ram body **252** reverses direction and the can body **2** contacts the stripper element **362**. Additionally, or in the alternative, the ram assembly **250** may include a can ejector such as, but not limited to, a pneumatic system that injects compressed air between the can body **2** and the punch **254**. The result is that the can body **2** is separated from the ram assembly **250** at a location between the tool pack **16** and the domer **500**.

As noted above, for a bodymaker **10** wherein the ram assemblies **250** forward stroke is upward, the take-away assemblies **18** are coupled to a housing assembly upper end **19**, i.e., generally above the ram assembly **250**. The take-away assemblies **18** are structured to grip or hold a can body **2** after the can body **2** is ejected from the ram assembly **250**. Each take-away assembly **18** is substantially similar and only one will be described below. Generally, the take-away assembly **18** is structured to lightly grip a can body **2** as the ram assembly **250** completes its forward stroke and to move the can body **2** away from the path of travel of the ram assembly **250** during the ram assembly return stroke. The take-away assembly **18** is further structured to reorient the can body **2** from a vertical orientation to a horizontal orientation.

As shown in FIGS. **13-17**, the take-away assembly **18** includes a drive assembly **600** and a can body transport assembly **670**. The drive assembly **600** includes a motor **602** and a support member **604** (FIGS. **15** and **16**). The take-away assembly motor **602** includes a rotating output shaft **606** coupled to a rotating drive sprocket **608**. The drive sprocket **608** is coupled to the drive assembly support member **604**. Thus, the take-away assembly motor **602** is operatively coupled to the drive assembly support member **604** and is structured to move the drive assembly support member **604**.

Further, the take-away assembly motor **602** is structured to provide an indexed motion to the drive assembly support member **604**. That is, the take-away assembly motor **602** is in either an actuated, first configuration, wherein the take-away assembly motor **602** provides motion to the drive assembly support member **604**, or in a stationary, second configuration, wherein the take-away assembly motor **602** does not provide motion to the drive assembly support member **604**. As discussed below, the motion of the take-away assembly motor **602** may be controlled by command signals provided to the take-away assembly motor **602** by a controller **782** (shown schematically) or sensors **784**, discussed below. Thus, the take-away assembly motor **602** is structured to receive and respond, i.e., react, to command signals from controller **782** or sensors **784**. In an alternative embodiment, the take-away assembly motor **602** is a servo-motor programmed to provide an indexed motion to the drive assembly support member **604**.

The drive assembly support member **604** is structured to support a number of gripping assemblies **672**, as discussed below. The drive assembly support member **604** is, in an exemplary embodiment, a tension member **610**. As used herein, a "tension member" is a construct that has a maximum length when exposed to tension, but is otherwise substantially flexible, such as, but not limited to, a chain or a belt. As shown in FIGS. **18** and **19**, and in an exemplary embodiment, tension member **610** is a roller chain **612**. Tension member **610** is, in an alternate embodiment (not shown), a timing belt. The roller chain **612** forms a generally horizontal loop **614** (FIG. **15**). The loop **614** includes a first end **616** and a second end **618**. The drive sprocket **608** is disposed at the loop first end **616** and an idler sprocket **609** is disposed at the loop second end **618**. The drive sprocket **608** engages the roller chain **612**. Thus, the drive assembly support member **604**, and in this embodiment the roller chain **612** moves in a generally horizontal direction. The drive assembly support member **604**, and in this embodiment the roller chain **612**, is disposed adjacent to the domer **500**. More specifically, the drive assembly support member **604** is disposed adjacent the gap between the tool pack **16** and the domer **500**. Thus, the drive assembly support member **604** is disposed adjacent to the location wherein a cup body is ejected from the ram assembly **250**. Further, the drive assembly support member **604** travels over a path **620** (or path of travel) that corresponds to generally horizontal loop **614**. That is, the drive assembly support member path **620** is also a horizontal loop including a first end **622** and a second end **624**.

The drive assembly **600** further includes a tension member support **630**. That is, a tension member **610** may sag and the tension member support **630** is structured to support and guide the tension member **610**. The tension member support **630** includes a lower support element **632** and an upper support element **634**. The lower support element **632** and upper support element **634** each include a distal surface **636**, **638** which defines a generally planar track **640**. The track **640** defines the path the tension member **610** follows. As shown, in an exemplary embodiment, the track **640** is generally oval.

The tension member **610**, in an exemplary embodiment, includes a number of lower support blocks **650** and upper support blocks **652**. The lower support blocks **650** and upper support blocks **652** are structured to be movably coupled to the lower support element **632** and the upper support element **634**, respectively. The lower support blocks **650** and upper support blocks **652** are coupled to, and in an exemplary embodiment fixed to, the tension member **610**. In an exemplary embodiment, the lower support blocks **650** and upper support blocks **652** are relatively small compared to the length of the tension member **610** and are spaced out over the length of the tension member **610**. The lower support blocks **650** are disposed on the lower side of tension member **610**, and more specifically the lower side of roller chain **612**. The upper support blocks **652** are disposed on the upper side of tension member **610**, and more specifically the upper side of roller chain **612**.

Each lower support block **650** and upper support block **652** includes a track engagement surface **654**, **656**, respectively. The track engagement surfaces **654**, **656** correspond to the shape of the lower and upper support element distal surfaces **636**, **638**. That is, as shown in FIG. **16**, in an exemplary embodiment the lower and upper support element distal surfaces **636**, **638** are rounded and the track engagement surfaces **654**, **656** are an arcuate groove **658**, **660**. The lower support block and upper support block track engagement surfaces **654**, **656** are movably coupled, and more specifically movably directly coupled, to the lower support element **632** or upper support element **634**, respectively. In this configuration the tension member **610** travels between the lower support element **632** and the upper support element **634**. In another embodiment, the tension member support **630** includes only a lower support element **632**. In such an embodiment, the tension member **610** travels over the lower support element **632**.

As shown in FIGS. **13** and **18-19**, the can body transport assembly **670** includes a number of gripping assemblies **672** and a reorienting chute **750**. The gripping assemblies **672** are substantially similar and only a single gripping assembly **672** will be described. Each gripping assembly **672**, shown in FIGS. **18** and **19**, is structured to travel across the path of the ram and to selectively grip a can body **2**. Each gripping assembly **672** includes a first base member **674** and a second base member **676**. Each first base member **674** and second base member **676** includes a body **677** having an outer side **678** and an inner side **679**. The first and second base outer side **678** and inner side **679** extend in a generally vertical plane. Each first base member **674** and second base member **676** includes a number of resilient elongated gripping members **680**. Each resilient elongated gripping member **680** extends generally horizontally from the first and second base outer side **678**. The gripping members **680** extending from the first base member **674** and second base member **676** are generally disposed in the same horizontal plane and, as such, are opposed to each other. That is, the gripping members **680** are opposed gripping members **680** which are opposed across a gripping space vertical axis **712** (discussed below).

Each first base member **674** and second base member **676** is coupled to the drive assembly support member **604** and, more specifically on the outer side of loop **614**. In an exemplary embodiment, second base member **676** is fixed to tension member **610**. Each first base member **674** is movably and selectively coupled to the drive assembly support member **604**. That is, each first base member **674** is adjustably coupled to the drive assembly support member **604** and may be shifted horizontally toward or away from the second base member **676**.

In an exemplary embodiment, each first base member **674** and second base member **676** includes a rigid mounting plate **690**. Each mounting plate **690** is disposed on the base member body inner side **679**. Each second base member **676** includes circular openings (not shown) through the body **677**. Fasteners **692** corresponding to the size of the circular openings extend through the body **677** and fix the second base member **676** to the mounting plate **690**. The mounting plate **690** is coupled, and in an exemplary embodiment fixed, to the drive assembly support member **604**. Each first base member **674** includes a horizontally elongated opening, i.e., a slot **694** through the body **677**. Fasteners **692** extend through the slot and couple the first base member **674** to the mounting plate **690**. The fasteners **692** on the first base member **674** may be loosened so as to allow the first base member **674** to be adjusted horizontally relative to the fixed second base member **676**. Thus, each first base member **674** is selectively positioned in one of a first position, wherein the first base member **674** has a first spacing from the second base member **676** or a second position, wherein the first base member **674** has a second spacing from the second base member **676**.

It is noted that each lower support block **650** and upper support block **652** may be coupled, and in an exemplary embodiment fixed, to a mounting plate **690**.

As noted above, each first base member **674** and second base member **676** includes a number of resilient elongated members **680**. In an exemplary embodiment, each first base member **674** and second base member **676** includes a plurality of elongated members **680**. As shown in FIGS. **18** and **19**, in one embodiment each first base member **674** and second base member **676** includes three elongated members **680**. Thus, there is a first set of elongated members **700** disposed on each first base member **674**, and, a second set of elongated members **702** disposed on each second base member **676**. The first and second sets of elongated members **700**, **702** are further disposed in opposing pairs. That is, as used herein, "opposing pairs" of elongated members **680** means that two elongated members **680** are in the same general horizontal plane and extend from different base members **674**, **676**. Further, the first base member **674** and second base member **676** are spaced from each other. Further, the elongated members **680** in a set **700**, **702** are aligned vertically. That is, each elongated member **680** has a proximal end **682** and a distal end **684**. Each elongated member proximal end **682** is directly coupled to one of the first or second base member bodies **677**. Further, each elongated member proximal end **682** is positioned on the first or second base member bodies **677** so that a vertical axis passes through each elongated member **680** that is coupled to that first or second base member bodies **677**.

In this configuration, each gripping assembly **672** defines an elongated gripping space **710**. The gripping space **710** has a generally vertical axis **712**. That is, the gripping space **710** is defined by the vertically aligned first set of elongated members **700** disposed to one side of the vertical axis **712** and the vertically aligned second set of elongated members **702** disposed on the opposing side of the vertical axis **712**. Alternatively stated, each gripping assembly **672** includes a number of pairs of opposed, resilient elongated members **680** that are disposed in opposition across a gripping space vertical axis **712**.

The pairs of opposed, resilient elongated members **680** are horizontally separated by a distance snuggly corresponding to the horizontal cross-sectional area of can body **2**. In this configuration, each gripping assembly **672** is sized to grip a can body **2**. As used herein, “grip” means the bias created when the gripping space **710** is slightly smaller than the size of the can body **2** and the resilient elongated members **680** are flexed outwardly when the can body **2** is moved into the gripping space **710**. “Grip” does not mean that the resilient elongated members **680** are flexed or otherwise biased inwardly in a manner similar to human fingers closing about an object.

As shown in FIGS. **18** and **19**, the resilient elongated members **680** are individually structured to allow a can body **2** to move into the gripping space **710**. The individual resilient elongated members **680** are substantially similar, with the resilient elongated members **680** disposed on the first and second base members **676**, **678** being generally mirror images, so a single resilient elongated member **680** will be described. As noted above, each elongated member **680** has a proximal end **682** and a distal end **684**. Further, each elongated member **680** has a generally rectangular cross-section including an inner side **686** and a lower side **688**. Each elongated member inner side **686** is substantially concave and has a curvature substantially corresponding to the perimeter of a can body **2**. Each elongated member lower side **688** includes an angled inner edge **689**. That is, as used herein, the “inner edge” is an angled surface created by truncating the vertex of the elongated member inner side **686** and elongated member lower side **688**.

The reorienting chute **750** is structured to reorient a can body **2** from a vertical orientation to a generally horizontal orientation. The reorienting chute **750** includes a vertical can body portion **752**, an arcuate transition portion **754**, and a horizontal can body portion **756**. The terms “vertical can body portion” and “horizontal can body portion” relate to the orientation of the can body **2** in the identified portion. The vertical can body portion **752** is elongated and extends generally horizontally. The vertical can body portion **752** includes a top guide **760**, a bottom guide **762**, an inner guide **764**, and an outer guide **766**. The vertical can body portion guides **760**, **762**, **764**, **766** define a passage **768** having a cross-sectional area shaped to correspond to a vertical cross-section of the can body **2**. The proximal ends, i.e., the end closest to the ram assembly, of the vertical can body portion guides **760**, **762**, **764**, **766** may be flared outwardly. The vertical can body portion **752** is disposed adjacent to the drive assembly support member path **620** and, more specifically, adjacent the drive assembly support member path first end **622**. The vertical can body portion **752** is sufficiently close to the drive assembly support member path first end **622** that, when a gripping assembly **672** is at the drive assembly support member path first end **622**, the resilient elongated members **680** extend into the vertical can body portion **752**.

The vertical can body portion inner guide **764**, which is disposed immediately adjacent the drive assembly support member path **620**, includes a number of generally horizontally extending slots **770**. The vertical can body portion inner guide slots **770** are sized to correspond to the resilient elongated members **680**. Further, the vertical can body portion inner guide slots **770** are positioned to align with the resilient elongated members **680**. Thus, as each first base member **674** and second base member **676** moves over the drive assembly support member path **620**, the resilient elongated members **680** on each first base member **674** and second base member **676** move into, a vertical can body portion inner guide slots **770**. Thus, at the proximal end of the vertical can body portion **752** the can body **2** being moved by a gripping assembly **672** is surrounded by the vertical can body portion **752** as well as the gripping assembly **672**.

As the gripping assembly **672** moves over the drive assembly support member path first end **622**, which is arcuate, the first base member **674** travels over the arcuate drive assembly support member path first end **622** and swings away from the vertical can body portion **752**. During this motion, the resilient elongated members **680** on a first base member **674** swing, i.e., move over an arc, out of the vertical can body portion **752**. Thus, as the gripping assembly **672** moves about the drive assembly support member path first end **622**, the first set of elongated members **700** and the second set of elongated members **702** spread apart as the first base member **674** travels over the drive assembly support member path first end **622** prior to the second base member **676**. This action releases the can body **2** from the gripping assembly **672**.

As the second base member **676** continues to move over the drive assembly support member path **620**, the second set of elongated members **702** push the can body toward the arcuate transition portion **754**. As the can body moves through the arcuate transition portion **754**, the can body is reoriented from a vertical orientation to a horizontal orientation. The can body **2** them moves into the horizontal can body portion **756**. The can body may then be picked up by conventional can track (not shown).

Thus, as noted above, the take-away assembly **18** is structured to lightly grip a can body **2** as the ram assembly **250** completes its forward stroke and to move the can body **2** away from the path of travel of the ram assembly **250** during the ram assembly return stroke. This process may be assisted by a take-away assembly control system **780**, which is part of a vertical bodymaker control system **800**, discussed below. Take-away assembly control system **780** includes a controller **782**, a number of sensors **784**, and a number of targets **786**. As used herein, a “target” is an object structured to be detected by a sensor **784**. A “target” may be, but is not limited to a ferromagnetic material, a pattern, and a signal producing device. For example, sensors **784** may be structured to detect when a ferromagnetic material is near. The controller **782** is in electronic communication with the take-away assembly motor **602** and the number of sensors **784**. The controller **782** is structured to produce command signals. As noted above, the take-away assembly motor **602** may respond to such command signals, e.g., the take-away assembly motor **602** may move into the first configuration in response to one command signal and move into the second configuration in response to another command signal. The sensors **784**, upon detecting a target **786**, provide a signal to the controller **782** which then generates the command signal. In an alternative embodiment, the sensors **784** are in electronic communication with the take-away assembly motor **602** and the sensors **784** produce the command signal.

In an exemplary embodiment, each sensor **784** is structured to detect a target **786** and to provide a command signal in response to detecting a target **786**. The drive assembly sensor **784** is disposed adjacent the drive assembly support member **604**. Further, each gripping assembly **672** includes a target **786**. As shown, a target **786** may be a ferromagnetic material, such as, but not limited to a nut, disposed on a fastener **692**. Thus, each time a gripping assembly **672** moves adjacent the sensor **784**, a command signal is generated and provided to the take-away assembly motor **602**. The command signal is generated and provided to the take-away assembly motor **602**. Another sensor (not shown, hereinafter the "lower sensor") may be disposed adjacent to an element of the operating mechanism **14**, such as, but not limited to, a redraw cam **274**. In this configuration, the element of the operating mechanism **14**, such as, but not limited to, a redraw cam **274**, is a "target." As the element of the operating mechanism **14** rotates or moves generally vertically, as described above, the lower sensor detects the element and provides a signal to the controller **782** or a command signal to the take-away assembly motor **602**.

In this configuration, the controller **782** or the sensors **784** may control the take-away assembly motor **602**. For example, if the take-away assembly motor **602** is in the actuated, first configuration, the drive assembly support member **604** is in motion along with the gripping assemblies **672**. As a gripping assembly **672** moves into position over the ram path of travel, a sensor **784** detects a target **786** on a gripping assembly **672**. That is, the sensor is positioned so as to detect a target **786** when a gripping assembly **672** moves into position over the ram path of travel. When this target **786** is detected, a command signal is provided to the take-away assembly motor **602** causing the take-away assembly motor **602** to move into the stationary, second configuration. Thus, the gripping assembly **672** is positioned over the ram path of travel. As described above, the ram assembly **250** moves a can body **2** into the space between the tool pack **16** and the domer **500**, which is also where the gripping assembly **672** is positioned.

As the can body **2** is ejected from the ram assembly **250**, as described above, the can body **2** is gripped by the gripping assembly **672**. As the operating mechanism **14** rotates, the redraw cam **274** moves past the lower sensor and a command signal is provided to the take-away assembly motor **602** and the take-away assembly motor **602** returns to the actuated, first configuration causing the drive assembly support member **604** to move and transfer the can body **2** to the reorienting chute **750** as described above. That is, the lower sensor is positioned to detect the redraw cam **274** when the ram assembly **250** is not in the second extended position. This cycle then repeats with each gripping assembly **672** stopping over the ram path of travel and picking up a can body **2**.

Put another way, when the ram assembly **250** is in the first position, the take-away assembly motor **602** is in the first configuration, and, when the ram assembly **250** is in the second position, the take-away assembly motor **602** is in the second configuration. Further, when the ram assembly **250** is in the second position, the gripping space vertical axis **712** is generally aligned with the ram assembly **250** longitudinal axis. In this configuration, the ram assembly **250** deposits a can body **2** in each gripping assembly **672** during a cycle.

Operation of the vertical bodymaker **10** may be directed by a vertical bodymaker control system **800**, shown schematically in FIG. **2**. The vertical bodymaker control system **800** includes a master control unit **802**, a number of sensor assemblies (a motor sensor assembly **804** is shown schematically in FIG. **9**), and a number of component control units **806**. The various elements of the vertical bodymaker control system **800** are in electronic communication with each other via hard line or wireless communication systems (neither shown). The sensor assemblies **804** are disposed on various elements of the vertical bodymaker **10** and are structured to generate data related to the various components. The sensor assemblies **804** further generate a signal incorporating the data which is communicated to the master control unit **802**. Such data is identified hereinafter as sensor data.

The master control unit **802**, in one embodiment, includes a programmable logic controller (not shown) as well as a memory device (not shown). The memory device includes executable logic, such as, but not limited to, computer code. The executable logic is processed by the programmable logic controller. That is, the programmable logic controller receives sensor data that is processed according to the executable logic. Based on the sensor data, as well as other input such as but not limited to a timer, the executable logic generates control unit data. The control unit data is then communicated to the various component control units **806**.

The component control units **806** are structured to control selected elements of the vertical bodymaker **10**. For example, the take-away assembly control system **780** discussed above is one component control unit **806**. Other component control units **806** include, but are not limited to, a cup feed assembly control unit, a motor control unit, and a pneumatic system control unit (none shown). Each component control unit **806** also includes a programmable logic controller (not shown) as well as a memory device (not shown). As described above, each component control unit **806** programmable logic controller processes executable logic or commands from the master control unit **802**. It is understood that each component control unit **806** is in electronic communication with a component that is electronically controlled.

For example, the motor control unit is electronically coupled to and structured to control operating mechanism motor **152**. A motor sensor assembly **804** (shown schematically in FIG. **9**) includes a rotary timing device **810** (FIG. **9**) such as, but not limited to, a resolver or encoder, that is structured to detect the position of the crankshaft **150**. The motor sensor assembly **804** generates crankshaft position data that is communicated to the master control unit **802**.

Further, the cup feed assembly control unit **806** is electronically coupled to, and structured to control, the rotatable feeder disk assembly motor (not shown). The cup feed assembly control unit **806** receives data from the master control unit **802** such as crankshaft position data. The cup feed assembly control unit **806** processes the crankshaft position data to determine when to actuate the rotatable feeder disk assembly motor (not shown). In an alternate embodiment, a cup feed assembly sensor assembly (not shown) determines and provides feeder disk position data to the master control unit **802**. The master control unit **802** processes the crankshaft position data and the feeder disk position data and sends a command signal to the cup feed assembly control unit **806** to actuate the rotatable feeder disk assembly motor at the proper time.

As a further example, the pneumatic system control unit is structured to control the pneumatic system (not shown). For example, the master control unit **802** processes the crankshaft position data and sends a command to the pneumatic system control unit actuating the pneumatic system to eject a can body **2** at the proper time as described above.

It is understood that the vertical bodymaker control system **800** is structured to ensure proper timing of the various components and the timing of the actions described above so that the actions occur at the proper time and to ensure the components do not interfere with each other.

While specific embodiments of the disclosed concept have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the disclosed concept which is to be given the full breadth of the claims appended and any and all equivalents thereof.

What is claimed is:

1. An operating mechanism for a vertically oriented bodymaker, said bodymaker including a housing assembly, said housing assembly including a number of elongated ram paths, said ram paths extending generally vertically, wherein said housing assembly includes a number of ram guides and slider channels, each said ram guide defining a generally vertical path of travel, each said slider channel defining a generally vertical path of travel, said operating mechanism comprising:

a crankshaft, said crankshaft rotatably coupled to said housing assembly, said crankshaft including a number of pairs of crankpin journals;

a motor, said motor operatively coupled to said crankshaft;

a link assembly including a number of links;

a number of ram assemblies each ram assembly including an elongated ram body, each said ram body structured to move over a ram path;

wherein a number of links from said link assembly extend between, and movably couple, each crankshaft crankpin journal to a ram body;

said link assembly include a link extending between said crankshaft and each said ram assembly, each said linkage including a connecting rod and a slider;

said slider including a body with two lateral sides, each said slider lateral side structured to be disposed in a slider channel;

each said connecting rod including a first end and a second end, said connecting rod first end including a rotational coupling, said connecting rod second end including a rotational coupling;

each said connecting rod body first end rotational coupling rotatably coupled to a crankpin journal; and

each said connecting rod body second end rotational coupling rotatably coupled to a slider body.

2. The operating mechanism of claim **1** wherein:

each said linkage includes a swing arm and a pivot rod;

each said swing arm includes a yoke including a first a first end and a second end, said yoke first end including a rotational coupling, said yoke second end including a rotational coupling;

each said pivot rod including a first end and a second end, said pivot rod first end including a rotational coupling, said pivot rod second end including a rotational coupling;

each said connecting rod first end rotational coupling directly rotatably coupled to a crankpin journal;

each said connecting rod second end rotational coupling rotatably coupled to a pivot rod first end rotational coupling;

each said pivot rod second end rotational coupling rotatably coupled to a slider body;

each said swing arm second end rotational coupling rotatably coupled to a connecting rod second end rotational coupling; and

each said swing arm rotatably coupled to said housing assembly.

3. A bodymaker comprising:

a housing assembly, said housing assembly including a number of elongated ram paths, said ram paths extending generally vertically;

a tool pack having a central passage, said central passage having an axis extending generally vertically, said tool pack coupled to the upper end of said housing assembly;

an operating mechanism including a crankshaft, a motor, a link assembly and a ram assembly;

said crankshaft rotatably coupled to said housing assembly;

said crankshaft including a number of pairs of crankpin journals;

said motor operatively coupled to said crankshaft;

said link assembly including a number of links;

said ram assembly including a number of elongated ram bodies, each said ram bodies movably structured to move over a ram path;

a number of links from said link assembly extending between, and movably coupled to both, a crankshaft crankpin journal and a ram body;

wherein each said pair of crankpin journals include opposing crankpin journals;

wherein said housing assembly includes a number of ram guides and slider channels, each said ram guide defining a generally vertical path of travel, each said slider channel defining a generally vertical path of travel;

said link assembly include a link extending between said crankshaft and each said ram assembly, each said link including a connecting rod and a slider;

said slider including a body with two lateral sides, each said slider lateral side structured to be disposed in a slider channel;

each said connecting rod including a first end and a second end, said connecting rod first end including a rotational coupling, said connecting rod second end including a rotational coupling;

each said connecting rod first end rotatably coupled to a crankpin journal; and

each said connecting rod second end rotatably coupled to a slider body.

4. The bodymaker of claim **3** wherein:

each said link includes a swing arm and a pivot rod;

each said swing arm including a yoke including a first end and a second end, said yoke first end including a rotational coupling, said yoke second end including a rotational coupling;

each said pivot rod including a first end and a second end, said pivot rod first end including a rotational coupling, said pivot rod second end including a rotational coupling;

each said connecting rod first end directly rotatably coupled to a crankpin journal;

each said connecting rod second end rotatably coupled to a pivot rod first end;

each said pivot rod second end rotatably coupled to a slider body;

each said swing arm first end rotatably coupled to a connecting rod second end; and

each said swing arm second end rotatably coupled to said housing assembly.

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